

Reducing illegal migrants in the U.S.: a dynamic CGE analysis

by

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References

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Summary

- (1) We use the USAGE-M model to simulate the effects on the U.S. economy of policies to restrict the employment of illegal migrants. A USAGE-M simulation consists of two runs: a basecase forecast run incorporating business-as-usual assumptions, and a policy run incorporating the policy under analysis. By comparing the results from the two runs, we generate the effects of the policy as percentage deviations in variables of interest away from their basecase forecast values.
- (2) In our basecase forecast, employment of foreign illegal workers grows from 7.3m in 2005 to 12.4m in 2019, an annual rate of growth of 3.8%. Rapid growth of illegal employment occurs despite only moderate growth (about 1% a year) in the net inflow of illegal migrants. The reason is that net inflow in 2005 was large, so that even if there were no growth in net inflow, the stock of illegal workers in the U.S. would increase rapidly. By contrast with the 3.8% annual growth in employment of illegal workers, employment of legal workers grows at an annual rate of only 1%.
- (3) We analyze two types of programs to lower the number of illegal migrants in U.S. employment:
 - a. Simulation SR: restricting supply by increasing the costs to illegal migrants of migrating to the U.S. (increased border security, higher smugglers fees, deportation, improved conditions in “Mexico”);
 - b. Simulation DR: restricting demand by increasing the costs of employing illegal migrants (taxes, fines).
- (4) The SR and DR simulations are scaled to have the same long-run effect on foreign-illegal employment. The policy shocks in both simulations cause employment of illegal migrants to be 28.6% less in 2019 than it otherwise would have been, that is they generate deviations of -28.6%. This reduces the average annual growth of illegal employment between 2005 and 2019 from the basecase level of 3.8% to 1.4%. The paper provides guidance on how to deduce from the SR and DR results the effects of policies of different scale.
- (5) With 28.6% cent fewer illegal workers, both simulations show negative deviations in the size of the economy in 2019 of about 1.6 %. Applied to the GDP of 2007, this is about \$200 billion.
- (6) The adjustment to a smaller economy would require a period in which the investment share in U.S. GDP was significantly weaker than it otherwise would have been. Both simulations show strong negative deviations in the early years for the I/GDP ratio.
- (7) During the period of weak investment, both simulations show negative deviations in the exchange rate with consequent positive deviations in exports and negative deviations in imports.
- (8) With the cut in illegal employment, both simulations show the expenditure components of GDP settling in the long run to levels between 0.8 and 2.7 per cent lower than they otherwise would have been.
- (9) Both simulations show positive long-run deviations in the terms of trade (the price of exports relative to the price of imports). This is a benefit of moving to a smaller economy. The long-run positive deviations in the terms of trade allow long-run positive deviations in the ratios of consumption and imports to GDP, supported by long-run positive deviations in the exchange rate. Both simulations show negative long-run deviations in the ratio of exports to GDP.

- (10) Macro, industry and occupational effects are quite similar in the two simulations, indicating that these effects are insensitive to the type of program used to lower illegal employment.
- (11) Industry effects mainly reflect macro results. An industry's current reliance on foreign illegal workers is relatively unimportant. Our results show industries with high reliance on foreign-illegal labor that perform relatively well in our simulations and others that perform relatively poorly. Ground maintenance and construction both have high reliance. Ground maintenance does relatively well because of its connection with private and public consumption. Construction does poorly because of its connection with investment. Similarly, our results show industries with low reliance on foreign-illegal labor that perform relatively poorly and others that perform relatively well. Machinery and Utilities both have low reliance. Machinery does relatively poorly because of its connection with exports and investment. Utilities does well because of its connection with consumption.
- (12) The programs increase jobs for domestic workers in the type of work performed by illegal migrants (e.g. construction laborers, drywall installers, miscellaneous agricultural workers, grounds maintenance workers, cooks, etc).
- (13) Measuring welfare by public and private consumption, we find that the legal population (domestic and legal migrant) are worse off under the programs. In the SR simulation, the loss in private and public consumption for the legal population is 0.52 per cent in 2019. Applied to private and public consumption of 2007, this is about \$60 billion. In the DR simulation, the loss in consumption for the legal population is 0.08 per cent in 2019, or about \$9 billion in 2007 equivalent terms.
- (14) The main negative effect on the legal population from a reduction in employment of foreign-illegal workers is that it increases the share of legal workers in low-wage occupations. We refer to this as the occupational-mix effect.
- (15) The type of program matters for the welfare effect. Demand-reducing taxation of illegal migrant employment (Simulation DR) is less damaging to the legal population than supply-reducing increases in the costs to illegal workers of entering the U.S (Simulation SR). The principal reason is illustrated by what we call Borjas diagrams, showing demand and supply curves for illegal labor. These diagrams demonstrate that both programs increase the cost per unit of foreign-illegal labor to employers. Supply-restricting programs allow the foreign-illegal employees who remain in the U.S. to capture the increase in cost as an increase in their wage rate. Demand-contracting programs, implemented by taxes and fines, transfer all of the cost increase (and more) to the U.S. Treasury.
- (16) The advantage of the DR over the SR approach depends crucially on our assumption that the DR policy is implemented as a pure transfer of money from employers of illegal migrants to the U.S. Treasury, a transfer does not involve dissipation of resources (capital and labor) by the employer. In a sensitivity simulation, we assume that demand restriction is implemented by criminal prosecutions and business closures, inducing employers to expend resources on lawyers, accountants and other professionals. In this case, the effect on the welfare of legal residents is similar to that in the SR simulation.

- (17) In both the SR and DR simulations we assume that public consumption per capita devoted to illegal migrants and their dependents in the U.S. is 49% of that devoted to legal residents. In a sensitivity simulation, we increase this percentage to 71%. Despite the prominence of the public expenditure issue in political discussions of illegal migrants, we find that this variation in the public expenditure assumption has only a minor impact on the welfare results for legal residents.
- (18) The effects of supply restriction are approximately proportional to the size of the program. A supply-restriction program that reduces long-run employment of illegal migrants in the U.S. by 57.2% has approximately twice as large an effect on all variables, including the welfare of legal residents, as a program that reduces long-run employment of illegal migrants by 28.6%.
- (19) The welfare effect on legal residents of a demand restriction program implemented by taxes and fines responds in a non-linear way to the size of the program. For a small program, for example one that reduces illegal employment in the long-run by 14.3%, the favorable effects generated from the suppression of illegal wage rates outweigh the unfavorable efficiency effects of losing workers whose marginal products exceed their wage rates. For a large program, for example one that reduces illegal employment in the long-run by 57.2%, the unfavorable efficiency effects outweigh the favorable wage-rate effects.
- (20) For both SR and DR programs of a given size, large variations in the USAGE-M parameters controlling the elasticity of demand by U.S. employers for illegal workers have relatively little effect on the welfare results for legal residents.
- (21) Similarly, large variations in parameters controlling the elasticity of supply to U.S. employers of illegal workers have relatively little effect on the welfare results for legal residents.
- (22) USAGE-M identifies six factors that determine the welfare result for legal residents of programs to restrict employment of illegal migrants:
1. Borjas effects covering changes in producer surplus via efficiency triangles and wage rectangles;
 2. effects on the skill composition of legal employment (occupation-mix);
 3. capital effects encompassing long-run changes in the wealth of legal residents and effects on taxes collected from capital owned by foreigners;
 4. effects on aggregate employment of legal residents;
 5. public expenditure effects; and
 6. effects on the U.S. terms of trade.
- The reason for the relative insensitivity of the welfare result for legal residents to changes in demand and supply parameters is that these changes impinge on only the first of the six factors.
- (23) The calculations in this paper do not incorporate the costs of implementing policies, that is the administrative costs of imposing taxes and fines, prosecuting employers and enhancing border security.

1. Introduction

There are about 7.5 million illegal migrants working in the U.S., accounting for nearly 5 per cent of total employment. These are people who have entered the U.S. illegally, mainly from Mexico or other parts of Latin America, or who have stayed in the U.S. beyond the expiry date on their visas.

Public attitudes in the U.S. to the illegal migrants vary across a wide spectrum, from the view that they are impoverishing poorer legal residents by depriving them of jobs to the view that they are a vital part of the U.S. economy because they perform tasks that legal residents are not willing to undertake. The illegal migrant issue is now a major component of the political debate with policy suggestions ranging from mass deportation to legalization and amnesty.

This paper provides some quantitative analysis that we hope will be helpful in informing policy discussions. We project the effects:

- on macroeconomic variables including GDP, aggregate employment, capital stock, exports, imports, investment and public and private consumption;
- on employment and wage rates by occupation for legal residents;
- on outputs and employment of industries; and
- on the overall welfare of legal residents;

of two broad approaches to reducing employment of illegal migrants. The first approach is to cut supply through tighter border security, deportation or other policies that reduce the desirability to potential illegal migrants of working in the U.S. The second approach is to cut demand through taxes and fines imposed on employers of illegal migrants or through criminal prosecutions of these employers.

In making our projections, we use USAGE¹, a detailed, dynamic CGE model of the U.S. economy. For the present project, we create a labor-market-extended version of USAGE, called USAGE-M. In this extension, we disaggregate the demand for labor by each industry into demands for workers classified by birth place (domestic and foreign), legal status (legal and illegal) and occupation (50 occupations emphasizing those in which illegal migrants are predominantly employed. We also disaggregate the supply side of the labor market into supplies by workers classified by birth place, legal status and recent labor-market function including working outside the U.S.

The paper is organized as follows. Section 2 describes the USAGE model and our main macro assumptions. Section 3 sets out the labor-market extension. This section is technical and can be skipped by readers who are not concerned with implementation details. All principal results in later sections are explained by back-of-the-envelope calculations incorporating familiar economic mechanisms that can be understood independently of section 3. Sections 4 and 5 describe and explain our simulations of supply restriction (the SR simulation) and demand restriction (the DR simulation). Section 6 presents sensitivity analysis covering the effects on our main results of changes in assumption concerning:

- resource costs imposed on employers by demand-side policies;
- provision of public services to illegal migrants and their families;
- the scale of programs to restrict the employment of illegal migrants;
- key parameters determining the elasticity of demand by U.S. employers for the services of illegal migrants with respect to their wage rate; and

¹ U.S. Applied General Equilibrium.

- key parameters determining the elasticity of supply to U.S. employers of illegal workers with respect to their wage rate.

Concluding remarks and suggestions for future research are in section 7.

2. The USAGE model and key macro assumptions

USAGE is a detailed, dynamic CGE model of the U.S. It has been developed at the Centre of Policy Studies, Monash University, in collaboration with the U.S. International Trade Commission.² The theoretical structure of USAGE is similar to that of the MONASH model of Australia (Dixon and Rimmer, 2002). However, in both its theoretical and empirical detail, USAGE goes beyond MONASH. USAGE can be run with up to 500 industries, 700 occupations and 51 regions (50 States plus the District of Columbia). While the standard version of USAGE contains considerable detail, we often find that further detail must be added to capture the essence of the issue under consideration. For this paper, we created a new version of USAGE with a labor-market-extension (section 3) designed to facilitate the analysis of issues concerning illegal migrants. This version is referred to as USAGE-M. It is implemented with 38 industries and 51 occupations. The first 50 occupations refer to jobs in the U.S. These occupations are chosen to retain maximum detail for activities in which illegal migrants are heavily employed. The 51st occupation is employment in the source countries for illegal migrants (e.g. Mexico). Inclusion of this occupation facilitates our modeling of inflows and outflows of illegal migrants.

USAGE includes three types of dynamic mechanisms: capital accumulation; liability accumulation; and lagged adjustment processes. Capital accumulation is specified separately for each industry. An industry's capital stock at the start of year $t+1$ is its capital at the start of year t plus its investment during year t minus depreciation. Investment during year t is determined as a positive function of the expected rate of return on the industry's capital. Expected rates of return can be determined by rational expectations (forward-looking) or static expectations in which only information from year t and earlier years is used.³ Liability accumulation is specified for the public sector and for the foreign accounts. Public sector liability at the start of year $t+1$ is public sector liability at the start of year t plus the public sector deficit incurred during year t . Net foreign liabilities at the start of year $t+1$ are specified as net foreign liabilities at the start of year t plus the current account deficit in year t plus the effects of revaluations of assets and liabilities caused by changes in price levels and the exchange rate. Lagged adjustment processes are specified for the response of wage rates to gaps between the demand for and the supply of labor by occupation. There are also lagged adjustment processes in USAGE for the response of foreign demand for U.S. exports to changes in their foreign-currency prices.

In a USAGE simulation of the effects of policy and other shocks, we need two runs of the model: a basecase or business-as-usual run and a policy run. The basecase is intended to be a plausible forecast while the policy run generates deviations away from the basecase caused by the policy under consideration. The basecase incorporates trends in industry technologies, household preferences and trade and demographic variables. These trends are estimated largely on the basis of results from historical runs in which USAGE is forced to track a piece of history. Most macro variables are exogenous in the basecase so that their paths can be set in accordance with forecasts made by expert macro forecasting groups such as the Congressional Budget Office. This requires endogenization of various macro

² Prominent applications of USAGE by the U.S. International Trade Commission include USITC (2004 and 2007).

³ The investment specification for the MONASH model, adopted in USAGE, is discussed in detail in Dixon *et al.* (2005)

propensities, e.g. the average propensity to consume. These propensities must be allowed to adjust in the basecase run to accommodate the exogenous paths for the macro variables.

The policy run in a USAGE study is normally conducted with a different closure (choice of exogenous variables) from that used in the basecase. In the policy run, macro variables must be endogenous: we want to know how they are affected by the policy. Correspondingly, macro propensities are exogenized and given the values they had in the basecase. More generally, all exogenous variables in the policy run have the values they had in the basecase, either endogenously or exogenously, with the exception of the policy variables of interest. Comparison of results from the policy and basecase runs then gives the effects of moving the policy variables of interest away from their basecase values. In the analyses in sections 4 and 5, the basecase and policy runs differ with regard to the values given to exogenous variables representing the costs to illegal migrants of coming to the U.S. and the costs to U.S. businesses of employing illegal migrants. We interpret the differences between the results in the basecase and the policy runs as the effects of policies that increase the obstacles faced at U.S. borders by potential illegal migrants and the effects of policies that impose fines and taxes on U.S. employers of illegal migrants.

In USAGE-based policy analyses, the policy closure introduces important background macroeconomic assumptions. Labor-market aspects of the assumptions introduced into the simulations reported in sections 4 and 5 are discussed in section 3. Other features of our policy closure and the corresponding macroeconomic assumptions are as follows.

2.1. Production technologies and household preferences

USAGE contains variables describing: primary-factor and intermediate-input-saving technical change in current production; input-saving technical change in capital creation; input-saving technical change in the provision of margin services; and input-saving changes in household preferences. In the policy runs described in sections 4 and 5, all of these variables are exogenous and kept on their basecase paths. Thus we assume that changes in immigration policy have no effect on technology or household preferences.

2.2. Inflation

In our policy closure, the price deflator for GDP is exogenous and set on its basecase path. Thus we assume that changes in immigration policy have no effect on inflation. Underlying this assumption is the idea that the Federal Reserve adjusts monetary policy to achieve a given inflation target.

2.3. Investment and rates of return

For this paper, the policy closure is set so that expected rates of return are generated by projecting current information. This is convenient because it allows the model to be solved recursively (in a sequence, one year at a time). We do not consider that the alternative, rational expectations, would add realism.

USAGE contains functions specifying the supply of funds for investment in each industry as an upward-sloping function of the industry's expected rate of return. Thus, in our policy runs, the model allows for short-run divergences in after-tax rates of return on industry capital stocks from their levels in the basecase run. Short-run increases/decreases in rates of return cause increases/decreases in investment and capital stocks. In this way, rate-of-return divergences in early years are gradually eroded.

2.4. Private and public consumption, and the public-sector deficit

In our policy closure, the average propensities for legal residents and illegal migrants to undertake private consumption out of household disposable income are exogenous. We set them on their basecase paths. Thus we assume that these propensities are not affected by immigration policy. In the case of illegal migrants, we assume that their savings are remitted to their home countries.⁴ Consequently, our policy runs capture the effects on the current account of reduced remittances associated reduced employment of illegal migrants.

In determining public consumption expenditure in our policy runs, we use the equation:

$$CPUB = F * \left(\frac{CPRIV(\text{leg})}{N(\text{leg})} \right) * N(\text{leg}) + \alpha * \left[F * \left(\frac{CPRIV(\text{leg})}{N(\text{leg})} \right) \right] * N(\text{ill}) \quad (2.1)$$

where

CPUB is the volume of public consumption;

CPRIV(leg) is private consumption by legal residents ;

N(ill) is the number of people in the U.S. in illegal migrant families (which we will call for convenience the number of illegal people);

N(leg) is the number of people in the U.S. in legal resident families (which we will call for convenience the number of legal people);

α is a parameter; and

F is a shift variable.

In the basecase run, F is endogenous and adjusts to make (2.1) compatible with extraneous forecasts for the path of public consumption (CPUB). In the policy closure, F is exogenous and is set on its basecase path. With F exogenous, (2.1) generates deviations in public consumption away from its basecase path as the sum of deviations in two components. The first component is public consumption devoted to legal people. We assume that as legal people become richer, they demand more public services. In particular we assume that public consumption devoted to each legal person is proportional to private consumption per legal person. The second component is public consumption devoted to illegal people. We assume that public consumption per capita devoted to illegal people is proportional to that devoted to legal people. Under this assumption, illegal people cannot be prevented from enjoying improvements in public amenities made available for legal people. As explained in Appendix 1 (to be made available by the authors), we set the factor of proportionality, α , at 0.49. This recognizes that: (a) illegal people do not have access to the full range of public facilities; and (b) the levels of some components of public expenditure, e.g. defense, are probably determined largely independently of the number of illegal people.

On the income-side of the public-sector budget, we assume in our policy runs that tax rates adjust to ensure that the public sector deficit follows its basecase path.

⁴ This assumption could be modified if we had data to suggest that not all of savings by illegal migrants are remitted. However, our remittance assumption is not important in determining the principal results in sections 4 to 6. If we assumed that illegal migrants kept their savings in the U.S., then our results would indicate increased ownership of U.S. assets by illegal migrants offset by reduced ownership by foreigners from outside the U.S. There would be little effect on our welfare results for legal residents.

3. The USAGE-M approach to modeling the labor market

3.1. Introduction

The six key ingredients in the labor market specification of USAGE-M are:

- (1) the division of the workforce into categories at start of each year reflecting workforce functions in the previous year;
- (2) the identification of workforce activities, that is what people do during the year;
- (3) the determination of labor supply from each category to each activity;
- (4) the determination of demand for labor in employment activities;
- (5) the specification of wage adjustment processes reflecting demand and supply; and
- (6) the determination of everyone's activity: who gets the jobs and what happens to those who don't?

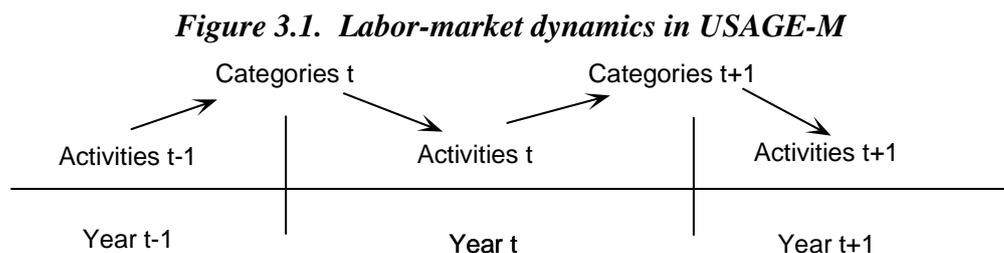
A broad picture of the specification can be obtained from Figure 3.1. We divide the workforce at the start of year t into categories. These categories reflect the activities that people undertook in year $t-1$, with the main activities being employment in occupations. The activities that people in a given category undertake in year t are determined mainly by their supply to that activity, relative to supply from people in other categories, and by demand for the services of that activity.

Table 3.1 lists the equations explained in this section that form the labor-market module of USAGE-M.

3.2. Workforce, categories, functions and activities

We adopt two concepts of workforce: the U.S. workforce and the extended workforce. The U.S. workforce is everyone of working age in the U.S excluding people in full time education and those who are ruled out of work by disabilities. Under this definition, the U.S. workforce includes discouraged workers and other people who are not actively seeking employment. The extended workforce is the U.S. workforce plus potential foreign illegal migrants working outside the U.S. For convenience we refer to these potential foreign illegal migrants as working in Mexico.

At the beginning of each year, we allocate people in the extended workforce to categories according to their birthplace, legal status and recent labor market function. We allow for two birthplaces, domestic⁵ and foreign, and two legal statuses, legal and illegal. All people with birthplace "domestic" have the status "legal". Some foreign residents of the U.S. are legal while others are illegal. We classify all workers in Mexico as illegal. This of course does not mean that Mexicans are working illegally in Mexico. It means that from the point of view of the U.S., Mexican workers in Mexico are potential foreign illegal migrants.



⁵ By domestic we mean people born in the U.S. or people who entered the U.S. as dependents of legal residents of the U.S.

Table 3.1. USAGE-M representation of the labor market

Numbers in each category at the beginning of year t

$$CAT_t((b, s, \ell)) = \sum_{ss \in \text{Legalstatus}} ACT_{t-1}((b, ss, \ell)) * T(b, ss, \ell, s) \quad (T3.1)$$

for all b, s and $\ell \neq \text{New}$

$$CAT_t(b, s, \text{New}) = \text{exogenous} \quad \text{for all } b \text{ and } s. \quad (T3.2)$$

Planned labour supply

$$L_t(c; a) = CAT_t(c) * \left[\frac{(B_t(c; a) * ATW_t(a))^\eta}{\sum_q (B_t(c; q) * ATW_t(q))^\eta} \right] \quad \text{for all categories } c \text{ and activities } a \quad (T3.8)$$

$$L_t(a) = \sum_c L_t(c; a) \quad \text{for all activities } a. \quad (T3.9)$$

Demand for labor and employment in the U.S.

$$D_t^1(j) = f_j^1(BTW_t^1(j); K_t(j); A_t(j)) \quad \text{for all U.S. industries } j \quad (T3.11)$$

$$BTW_t^1(j) = g_j^1(BTW_t(b, s, o) \forall b, s \text{ and U.S. occupations } o) \quad \text{for all U.S. industries } j \quad (T3.12)$$

$$D_t(b, s, o, j) = D_t^1(j) * h_{b,s,o,j}(BTW_t(bb, ss, oo) \forall bb, ss \text{ and U.S. occupations } oo) \quad \text{for all } b, s \text{ and U.S. occupations and industries } o \text{ and } j \quad (T3.17)$$

$$D_t(b, s, o) = \sum_j D_t(b, s, o, j) \quad \text{for all } b, s \text{ and U.S. occupations } o. \quad (T3.18)$$

$$E_t(b, s, o) = D_t(b, s, o) \quad \text{for all } b, s \text{ and U.S. occupations } o. \quad (T3.19)$$

Relationship between after-tax and before-tax wage rates

$$ATW_t(b, s, o) = BTW_t(b, s, o) * (1 - T_t(b, s)) \quad \text{for all } b, s \text{ and U.S. occupations } o \quad (T3.20)$$

$$ATW_t(b, s, u) = BTW_t^{\text{ave}}(b, s) * F_t(b, s) \quad \text{for all } b, s \text{ and unemployment functions } u \quad (T3.21)$$

Wage adjustment

$$\frac{ATW_t(b, s, o)}{ATW_t^{\text{base}}(b, s, o)} - \frac{ATW_{t-1}(b, s, o)}{ATW_{t-1}^{\text{base}}(b, s, o)} = \beta \left(\frac{D_t(b, s, o)}{D_t^{\text{base}}(b, s, o)} - \frac{L_t(b, s, o)}{L_t^{\text{base}}(b, s, o)} \right), \quad \text{for all } (b, s) \text{ and all U.S. occupations } o \quad (T3.22)$$

Vacancies, and movements into employment activities

$$V_t(a) = E_t(a) - H_t[a; a] \quad \text{for all U.S. employment activities } a \quad (T3.23)$$

$$H_t(c; a) = V_t(a) * \left[\frac{L_t(c; a)}{\sum_{s \neq a} L_t(s; a)} \right], \quad \text{for all categories } c \neq a \text{ and all U.S. employment activities } a. \quad (T3.24)$$

$$H_t(c; c) = CAT_t(c) - \sum_{a \neq c} H_t(c; a), \quad \text{for all employment categories } c \text{ (including Mexico)} \quad (T3.25)$$

Table 3.1 continues ...

Table 3.1 continued

Movements into unemployment and Mexican activities

$$H_t(c; u) = \begin{cases} L_c(c; u) + \mu(c) * CAT_t(c) & \text{for short – run unemployment activities } u \\ 0 & \text{for long – run unemployment activities } u \end{cases}$$

for all U.S. employment categories c , (T3.26)

$$H_t(c; u) = \begin{cases} 0 & \text{for short – run unemployment activities } u \\ CAT_t(c) - \sum_{a \in \text{employment activ}} H_t(c; a) & \text{for long – run unemployment activities } u \end{cases}$$

for all U.S. unemployment categories c and all unemployment activities u (T3.27)

$$H_t(c; u) = \begin{cases} CAT_t(c) - \sum_{a \in \text{U.S. employ activ}} H_t(c; a) & \text{for } c \text{ not foreign, illegal and for short – run unemploy activ } u \\ CAT_t(c) - \sum_{a \in \text{U.S. employ activ}} H_t(c; a) & \text{for } c \text{ foreign, illegal and for Mexican activities } u \\ 0 & \text{otherwise} \end{cases}$$

for all New categories c and all unemployment or Mexican activities u . (T3.28)

$$H_t(c; u) = \begin{cases} L_t(c; u) & \text{for } c \text{ non – Mexican} \\ CAT_t(c) - \sum_{a \in \text{U.S. employ activ}} H_t(c; a) & \text{for } c \text{ Mexican} \end{cases}$$

for all non-New categories c and for Mexican activities u (T3.29)

$$\sum_c H_t(c, a) = E_t(a) \text{ , for all U.S. unemployment activities and Mexican activities } a \text{ (T3.30)}$$

Notation

$CAT_t((b, s, \ell))$ is the number of people at the start of year t who are from birthplace b , have legal status s and who performed workforce function ℓ in year $t-1$.

$CAT_t((b, s, \text{New}))$ is the number of people at the start of year t who are from birthplace b , have legal status s and were not in the extended workforce in year $t-1$.

$ACT_{t-1}((bb, ss, \ell))$ is the number of people in activity (bb, ss, ℓ) in year $t-1$.

$T(b, ss, \ell, s)$ is the proportion of people in activity (b, ss, ℓ) in year $t-1$ who are allocated to category (b, s, ℓ) at the start of year t .

$L_t(c; a)$ is the labor supply that people in category c make to activity a . Both c and a are (b, s, ℓ) triples.

$L_t(a)$ is total labor supply to activity a .

$L_t^{\text{base}}(a)$ is the base or forecast value of $L_t(a)$.

β is a positive parameter.

$ATW_t(a)$ is the real after-tax wage rate of labor in activity a (for non-employment activities it is a social security payment or other support).

$ATW_t^{\text{base}}(a)$ is the base or forecast value of $ATW_t(a)$.

η is a parameter reflecting the ease with which people feel that they can shift between activities.

$B_t(c; a)$ is a variable reflecting the preference of people in category c for earning money in activity a in year t .

$K_t(j)$ is industry j 's capital stock.

$BTW_t^1(j)$ is the overall real before-tax wage rate to the industry.

$A_t(j)$ is a vector of variables that influence industry j 's demand for labor.

$D_t^1(j)$ is labor input to industry j .

Table 3.1 continues ...

Table 3.1 continued

| |
|---|
| $BTW_t(b,s,o)$ is the real before-tax wage rate of workers of birthplace b , legal status s and U.S. occupation o . |
| $D_t(b,s,o,j)$ is j 's input of labor of birthplace b , legal status s and U.S. occupation o . |
| $D_t(b,s,o)$ is aggregate demand for (b,s,o) labor. |
| $D_t^{base}(b,s,o)$ is the base or forecast value of $D_t(b,s,o)$. |
| $E_t(b,s,o)$ is employment of (b,s,o) labor. |
| $T_t(b,s)$ is the payroll and income-tax rate applying to all (b,s) workers in the U.S. |
| $BTW_t^{ave}(b,s)$ is the average real before-tax wage rate of (b,s) workers in the U.S. |
| $F_t(b,s)$ is the fraction of $BTW_t^{ave}(b,s)$ that (b,s) people receive in unemployment activities from social security payments or other support. |
| $V_t(a)$ is vacancies in activity a . |
| $H_t[c; a]$ is the flow of people from category c to activity a . |
| $\mu(c)$ is the fraction of people of category c people who become involuntarily unemployed. |

A person's recent workforce function refers to what he or she did in the labor market in the previous year, year $t-1$. The functions we identify are:

- employed in occupation m , where m is one of the 50 U.S. occupations identified in USAGE-M;
- short-run unemployed in the U.S., that is unemployed for a substantial amount of year $t-1$ but not unemployed in year $t-2$;
- long-run unemployed in the U.S., that is unemployed for a substantial amount of year $t-1$ and also of year $t-2$;
- living in the U.S. but not in the workforce;
- employed in the single Mexican occupation recognized in USAGE-M;
- living in Mexico but not in the workforce.

A final concept that we need to explain before setting out the algebra of the labor-market specification is activity. Activities are defined by birthplace, legal status and workforce function in the current year. Examples of activities in year t are: working in the U.S. as a domestic-legal construction laborer; working in the U.S. as a foreign-illegal cook; and experiencing short-run unemployment in the U.S. as a foreign legal resident. Another activity is working as a foreign illegal in Mexico. As already mentioned, we do not wish to imply that Mexicans are working illegally in Mexico. As we will see, Mexican workers in Mexico will be modeled as potential entrants to foreign illegal work activities in the U.S.

The link (the upward-sloping arrows in Figure 3.1) between the number of people in different activities in year $t-1$ and the number of people in each category at the start of year t is specified by the equations:

$$CAT_t((b,s,\ell)) = \sum_{ss \in \text{Legalstatus}} ACT_{t-1}((b,ss,\ell)) * T(b,ss,\ell,s) \quad (3.1)$$

for all b, s and non-new functions, i.e. $\ell \neq \text{New}$

$$CAT_t((b,s,\text{New})) = \text{exogenous} \quad \text{for all } b \text{ and } s. \quad (3.2)$$

In these equations,

$CAT_t((b,s,\ell))$ is the number of people at the start of year t who are from birthplace b , have legal status s and who performed workforce function ℓ in year $t-1$.

$CAT_t((b,s,New))$ is the number of people at the start of year t who are from birthplace b , have legal status s and were not in the extended workforce in year $t-1$, that is the number of new (b,s) entrants to the extended workforce. If b is domestic and s is legal, then we have in mind high school and college graduates entering the job market in the U.S. If b is foreign and s is legal, then we have in mind newly admitted legal migrants of working age. If b is foreign and s is illegal, then we have in mind high school and college graduates entering the workforce in Mexico. There is no-one in the category domestic-illegal-new. As indicated in (3.2), the numbers of people in “New” categories is set exogenously, reflecting demographic factors.

$ACT_{t-1}((bb,ss,\ell))$ is the number of people in activity (bb,ss,ℓ) in year $t-1$, that is the number of people who, in year $t-1$, belonged to birthplace bb , had legal status ss and labor-force function ℓ .

$T(b,ss,\ell,s)$ is the proportion of people in activity (b,ss,ℓ) in year $t-1$ who are allocated to category (b,s,ℓ) at the start of year t : we assume that people never change their birthplace.⁶

In the simulations reported in sections 4 and 5, we set

$$T(b,ss,\ell,s) = \begin{cases} 0.99 & \text{for all } \ell \text{ and } b, \text{ and for all } s,ss \text{ such that } s = ss \\ 0.00 & \text{otherwise} \end{cases} . \quad (3.3)$$

Under (3.3), we assume that no-one changes legal status, and that one per cent of people in every activity in year $t-1$ drop out of the extended workforce at the beginning of year t , either through retirement or death. More sophisticated transition assumptions are possible. To allow for legalization of some foreign illegals in the U.S. and for differences in retirement/death rates across activities, we could set $T(b,ss,\ell,s)$ according to:

$$T(b,ss,\ell,s) = \text{Survive}(b,ss,\ell) * P(s|ss,\ell) \quad (3.4)$$

where

$\text{Survive}(b,ss,\ell)$ is the proportion of people in activity (b,ss,ℓ) in year $t-1$ who remain in the extended workforce in year t ; and

$P(s|ss,\ell)$ is the probability of a surviving person who had legal status ss and workforce function ℓ in year $t-1$ achieving legal status s at the start of year t .

In (3.4), we continue to assume that people cannot change their birthplace but we allow for the possibility of changes in legal status. In future research we could investigate the implications of legalization programs by simulating the effects of suitable shocks to $P(s|ss,\ell)$ for $ss = \text{illegal}$, $s = \text{legal}$ and $\ell \neq \text{Mexico}$.

⁶ Consistent with the definition of a category, only people from activities with workforce function ℓ in year $t-1$ are allocated to categories with workforce function ℓ at the start of year t .

3.3. Labor supply from each category to each activity

USAGE-M specifies labor supply from people in each category to each activity. Via these specifications, we ensure that people in a category with birthplace b and legal status s make offers only to activities with these characteristics. Thus, people in the category domestic-legal construction laborer can offer only to activities with the domestic and legal characteristics. Most of these people offer to the activity domestic-legal construction laborer, that is they offer to continue their employment of last year. However, some will offer to change occupation in response to changes in relative wages and a few will offer to unemployment. Some people in the category foreign-illegal Mexico will offer to foreign-illegal occupations in the U.S., that is they will seek to enter the U.S. as illegal migrants, and some people in foreign-illegal categories operating in the U.S. will make offers to the activity foreign-illegal Mexico, that is they will offer to return home. In making these decisions, people in these foreign-illegal categories compare wages in Mexico with wages for foreign-illegal occupations in the U.S.

In developing the labor-supply functions for USAGE-M, we assume that at the beginning of year t , people in category c [where c is a (birthplace, legal status, function) triple] decide their offers to activity a [where a is also a (b, s, ℓ) triple] for the year by solving a problem of the form: choose $L_t(c; a)$, for all activities a

$$\text{to maximize } U_c [ATW_t(a) * L_t(c; a) \quad \forall \text{ activities } a] \quad (3.5)$$

$$\text{subject to } \sum_a L_t(c; a) = CAT_t(c) \quad (3.6)$$

where

$L_t(c; a)$ is the labor supply that people in category c make to activity a ;

$CAT_t(c)$ is the number of people in category c ;

$ATW_t(a)$ is the real after-tax wage rate of labor in activity a (for non-employment activities, that is short-and long-run unemployment, $ATW_t(a)$ can be thought of as a social security payment or other support); and

U_c is a homothetic function with the usual properties of utility functions (positive first derivatives and quasi-concavity).

In (3.5) and (3.6), people in category c treat dollars earned in different activities as imperfect substitutes. This is a convenient and flexible specification through which we can allow labor supplies to shift between activities in response to changes in after-tax rewards. By specifying a separate utility function for each c , we can ensure that each category makes supplies to activities that are compatible with the category's birthplace, legal status and occupational characteristics.

In the application presented in sections 4 and 5, U_c has the CES form:

$$U_c = \left[\sum_a (B_t(c; a) * ATW_t(a) * L_t(c; a))^{\frac{\eta}{1+\eta}} \right]^{\frac{1+\eta}{\eta}} \quad (3.7)$$

where

η is a parameter reflecting the ease with which people feel that they can shift between activities; and

$B_t(c;a)$ is a variable reflecting the preference of people in category c for earning money in activity a in year t .

The $B_t(c;a)$'s play two roles in our analysis. The first is via their initial settings, that is the values assigned to them in the base year, 2004, data.

- By setting $B_{2004}(c;a)$ at 0 if the birthplace and legal characteristics of c differ from those of a , we ensure that people in categories with birthplace b and legal status s offer labor only to (b,s) activities.
- By setting $B_{2004}(c;a)$ at relatively high values when c and a agree in their (b,s) characteristics and have a functional characteristic referring to the same occupation, we ensure that most people employed in year $t-1$ in occupation m (including the Mexican occupation) offer to continue to work in m in year t .
- By setting $B_{2004}(c;a)$ at suitably chosen positive values when c and a agree in their (b,s) characteristics but have functional characteristics referring to different occupations, we ensure that people make offers to work in occupations compatible with their skills.
- By setting $B_{2004}(c;a)$ at zero where the functional characteristic of c is either short-run or long-run unemployment and the functional characteristic of a is short-run unemployment, we ensure that no-one can stay in short-run unemployment in successive years or move from long-run unemployment back to short-run unemployment.
- By setting $B_{2004}(c;a)$ at a moderately large value where c and a agree in their (b,s) characteristics and c has the functional characteristic of short-run unemployment and a has the functional characteristic long-run unemployment, we introduce a mild discouraged-worker effect for people suffering short-run unemployment.
- By setting $B_{2004}(c;a)$ at a larger value where c and a agree in their (b,s) characteristics and where c and a both have the functional characteristic of long-run unemployment, we introduce a stronger discouraged-worker effect for the long-run unemployed.

The second role of the $B_t(c;a)$'s is to carry shocks in policy runs. In section 4, we represent the impact of tighter border security by reductions in the $B_t(c;a)$'s where c and a both have the (b,s) characteristics foreign illegal and c has the functional characteristics of either Mexico or New and a has the functional characteristic of a U.S. occupation.

Under (3.7), problem (3.5) - (3.6) generates labor-supply functions of the form:

$$L_t(c; a) = CAT_t(c) * \left[\frac{(B_t(c; a) * ATW_t(a))^\eta}{\sum_q (B_t(c; q) * ATW_t(q))^\eta} \right]. \quad (3.8)$$

Total supply of labor to activity a is obtained as

$$L_t(a) = \sum_c L_t(c; a) \quad \text{for all activities } a. \quad (3.9)$$

In the simulations in sections 4 and 5 we set η in (3.8) at 2. For understanding what this means, it is useful to express (3.8) in percentage change form as:

$$\ell_t(c; a) = cat_t(c) + \eta * (atw_t(a) - atw_t^{ave}(c)) + \eta * (b_t(a) - b_t^{ave}(c)). \quad (3.10)$$

In (3.10), the lowercase symbols $\ell_t(c; a)$, $\text{cat}_t(c)$, $\text{atw}_t(a)$ and $b_t(a)$ are percentage changes in the variables denoted by the corresponding uppercase symbols, and $\text{atw}_t^{\text{ave}}(c)$ and $b_t^{\text{ave}}(c)$ are weighted averages of the $\text{atw}_t(q)$ s and $b_t(q)$ s with the weights reflecting the share of activity q in the offers from people in category c . Thus (3.10) implies that people in category c will switch their offers towards activity a if the wage rate in activity a rises relative to an average of the wage rates across all the activities in which category- c people could participate. With η set at 2, we assume that the number of people who wish to change jobs, in particular the number of people who wish to move from Mexico to U.S. occupations, is quite sensitive to changes in relative wage rates. However, an increase in $\text{ATW}_t(a)$ does not have much affect on $L_t(a;a)$. This is because the bulk of offers from people in category a are to activity a , so that $\text{atw}_t(a) - \text{atw}_t^{\text{ave}}(a)$ is always close to zero. The major part of the supply of labor to any work activity a is from incumbents [that is, $L_t(a;a)$ is a very large fraction of $L_t(a)$]. Thus, even with η as high as 2, the elasticity of supply of labor to activity a with respect to the wage rate in a is relatively low. Analysis of the sensitivity of our principal results to variations in η is described in subset 6.5.

3.4. Demand for labor in the U.S.

The labor input, $D_t^1(j)$, to U.S. industry j in year t is specified in USAGE-M along conventional CGE lines as a function of: the industry's capital stock, $K_t(j)$; the overall real before-tax wage rate to the industry, $\text{BTW}_t^1(j)$; and other variables, $A_t(j)$, that influence industry j 's demand for labor, including technology and commodity prices:

$$D_t^1(j) = f_j^1(\text{BTW}_t^1(j); K_t(j); A_t(j)). \quad (3.11)$$

The overall real wage rate to industry j is determined as a suitable average of the real wage rates applying to the types of labor that the industry employs:

$$\text{BTW}_t^1(j) = g_j^1(\text{BTW}_t(b,s,o) \text{ for all } b,s \text{ and U.S. occupations } o), \quad (3.12)$$

where

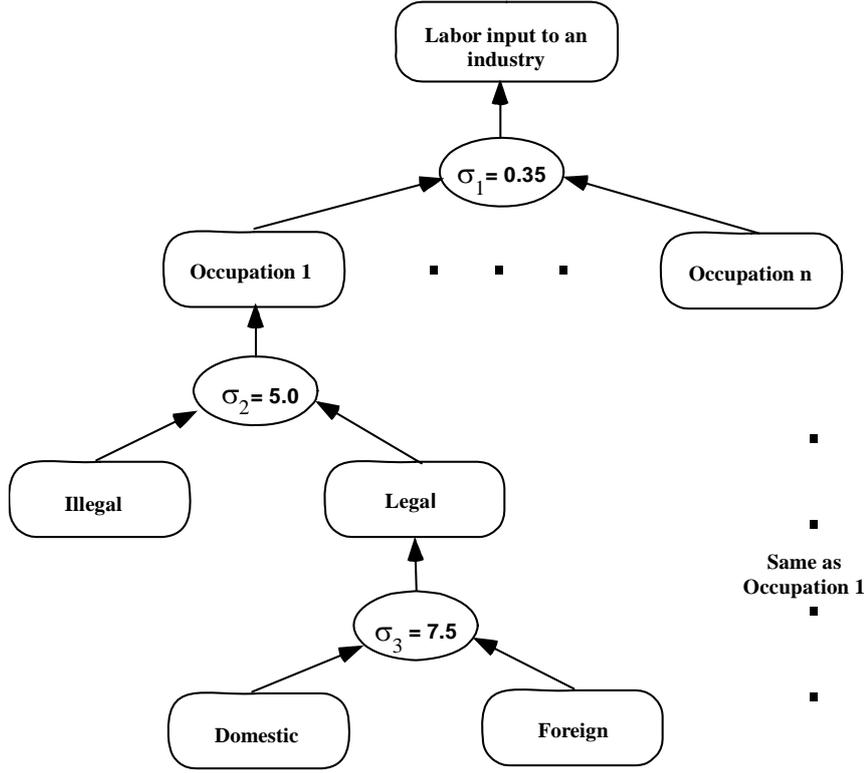
$\text{BTW}_t(b,s,o)$ is the real before-tax wage rate of workers of birthplace b , legal status s and U.S. occupation o .

Within industry j 's labor input, the demand for labor by birthplace, legal status and occupation is determined by a nested CES cost minimization problem. The nesting and the substitution elasticities are indicated in Figure 3.2. We assume that there are low substitution possibilities between occupations (substitution elasticity of 0.35) but high substitution possibilities between legal and illegal workers of the same occupation (substitution elasticity of 5) and between domestic and foreign legal workers of the same occupation (substitution elasticity of 7.5). Our choice of 7.5 for the domestic/foreign substitution elasticity is suggested by the econometric work of Ottaviano and Peri (2006). The other substitution elasticities represent judgments. Subsection 6.4 contains relevant sensitivity analysis.

In algebraic terms, we assume that industry j satisfies its labor requirements by choosing:

$$D_t(b,s,o,j), j\text{'s input of labor of birthplace } b, \text{ legal status } s \text{ and U.S. occupation } o,$$

Figure 3.2. Nesting assumptions in the creation of the labor input to each industry



$D_t^3(s, o, j)$, j 's input of labor of legal status s and U.S. occupation o , defined as a CES aggregate over b of (b, s, o, j) inputs, and

$D_t^2(o, j)$, j 's input of labor of U.S. occupation o , defined as a CES aggregate over s of (s, o, j) inputs,

$$\text{to minimize } \sum_{b,s,o} BTW_t(b, s, o) * D_t(b, s, o, j) \quad (3.13)$$

$$\text{subject to } D_t^1(j) = CES_o \left[D_t^2(o, j) \right] \quad (3.14)$$

$$D_t^2(o, j) = CES_s \left[D_t^3(s, o, j) \right] \text{ for all U.S. occupations } o, \quad (3.15)$$

$$\text{and } D_t^3(s, o, j) = CES_b \left[D_t(b, s, o, j) \right] \quad (3.16)$$

for all U.S. occupations o and legal status s ⁷.

The CES functions in (3.14) to (3.16) incorporate the elasticities shown in Figure 3.2 and are calibrated to reflect the data described in Appendix 2 (to be made available by the authors) on the occupational, birthplace and legal status of workers in U.S. industries.

⁷ As shown in Figure 3.2, there is no level 3 CES nest when $s = \text{illegal}$ (only foreigners can provide illegal labor. However, it is unnecessarily clumsy to include this detail in the algebraic overview of our theory. We can simply assume that industries use tiny amounts of domestic illegal labor.

From problem (3.13) – (3.16) we obtain demand functions of the form

$$D_t(b, s, o, j) = D_t^1(j) * h_{b,s,o,j} \left(BTW_t(bb, ss, oo) \quad \forall bb, ss \text{ and U.S. occupations } oo \right)$$

for all b, s and U.S. occupations and industries o and j. (3.17)

These can be aggregated across industries to determine aggregate demand for (b,s) workers in U.S. occupation o as

$$D_t(b, s, o) = \sum_j D_t(b, s, o, j) \quad \text{for all b, s and U.S. occupations } o \quad . \quad (3.18)$$

We assume that employment of (b,s) workers in U.S. occupation o, $E_t(b, s, o)$, is determined by demand:

$$E_t(b, s, o) = D_t(b, s, o) \text{ for all b, s and U.S. occupations } o \quad . \quad (3.19)$$

3.5. Relationship between after-tax and before-tax wage rates in the U.S.

As can be seen from the previous sub-sections, after-tax wage rates are important in motivating labor supply while before-tax wage rates motivate demand. To relate after-tax wage rates to before-tax wage rates we include in USAGE-M:

$$ATW_t(b, s, o) = BTW_t(b, s, o) * (1 - T_t(b, s)) \quad \text{for all b, s and U.S. occupations } o \quad (3.20)$$

$$ATW_t(b, s, u) = BTW_t^{ave}(b, s) * F_t(b, s) \quad \text{for all b, s and unemployment functions } u. \quad (3.21)$$

In these equations,

$T_t(b, s)$ is the payroll and income-tax rate applying to all (b,s) workers in the U.S.;

$BTW_t^{ave}(b, s)$ is the average real before-tax wage rate of (b,s) workers in the U.S.; and

$F_t(b, s)$ is the fraction of $BTW_t^{ave}(b, s)$ that (b,s) people receive in unemployment activities from social security payments or other support. In the simulations described in sections 4 and 5, we assume that the $F_t(b, s)$'s are unaffected by changes in immigration policies, that is we assume that percentage movements in unemployment benefits match those in average before-tax wage rates.

As can be seen in section 5, in the policy run on the effects of increasing the costs to employers of using foreign-illegal labor, the shock is an increase in $T_t(b, s)$ for $b = \text{foreign}$ and $s = \text{illegal}$.

3.6. Wage adjustment

In policy runs, we assume that wage rates adjust according to the equation:

$$\frac{ATW_t(b, s, o)}{ATW_t^{base}(b, s, o)} - \frac{ATW_{t-1}(b, s, o)}{ATW_{t-1}^{base}(b, s, o)} = \beta \left(\frac{D_t(b, s, o)}{D_t^{base}(b, s, o)} - \frac{L_t(b, s, o)}{L_t^{base}(b, s, o)} \right) ,$$

for all (b,s) and all U.S. occupations o (3.22)

where the superscript “base” refers to values in the basecase forecast and β is a positive parameter.

This equation implies that if a policy causes the market for (b,s,o) employment in year t to be tighter than it was in the basecase forecast (i.e., if the policy causes a larger percentage deviation in demand than supply), then there will be an increase between years

t-1 and t in the deviation in (b,s,o)'s real after-tax wage rate. In other words, in periods in which a policy has elevated demand relative to supply, real wages will grow relative to their basecase values. Figure 3.3 illustrates the operation of equation (3.22) for a model with a single employment activity.

Our assumed wage-adjustment process is compatible with a search model [see for example, Bohringer *et al.* (2005)] in which reductions in labor supply, and resulting reductions in the unemployment rate, generate decreases in the value of having a job relative to the value of not having a job, thereby emboldening workers to demand higher wage rates. It is also compatible with efficiency-wage theory, see for example, Layard *et al.* (1994, pp. 33-45). Under this theory, employers offer wage rates that optimise worker effort per dollar of wage cost. The theory suggests that the effort-optimising wage rate rises when there is a decrease in labor supply and a consequent temporary decrease in unemployment.

In the context of USAGE-M, we can think of equation (3.22) as having the role of determining after-tax wage rates for occupations in the U.S. Then at given tax rates, equations (3.20) and (3.21) determine before-tax wage rates for these occupations and for unemployment. The only other wage rate in our model is the after-tax wage rate in Mexico. We set this exogenously.

3.7. The determination of everyone's activity: who gets the jobs and what happens to those who don't?

Under (3.22), markets for U.S. occupations do not clear. Consequently, we need to specify which offers to employment are accepted and what activities are undertaken by those whose offers to employment are not accepted. In terms of Figure 3.1, we need to specify the downward sloping arrows.

In linking categories at the start of year t to activities in year t, we specify an equation for the flow from each category c to each activity a, $H_t(c;a)$.

Flows from all categories to employment in U.S. occupations (area 1 in Figure 3.4)

We start by defining vacancies in U.S. employment activity a in year t as employment, $E_t(a)$, less the number of jobs filled in the activity by people in category a, that is vacancies in a are jobs less those filled by incumbents:

$$V_t(a) = E_t(a) - H_t[a ; a] \quad \text{for all U.S. employment activities a} \quad (3.23)$$

where

$V_t(a)$ is vacancies and

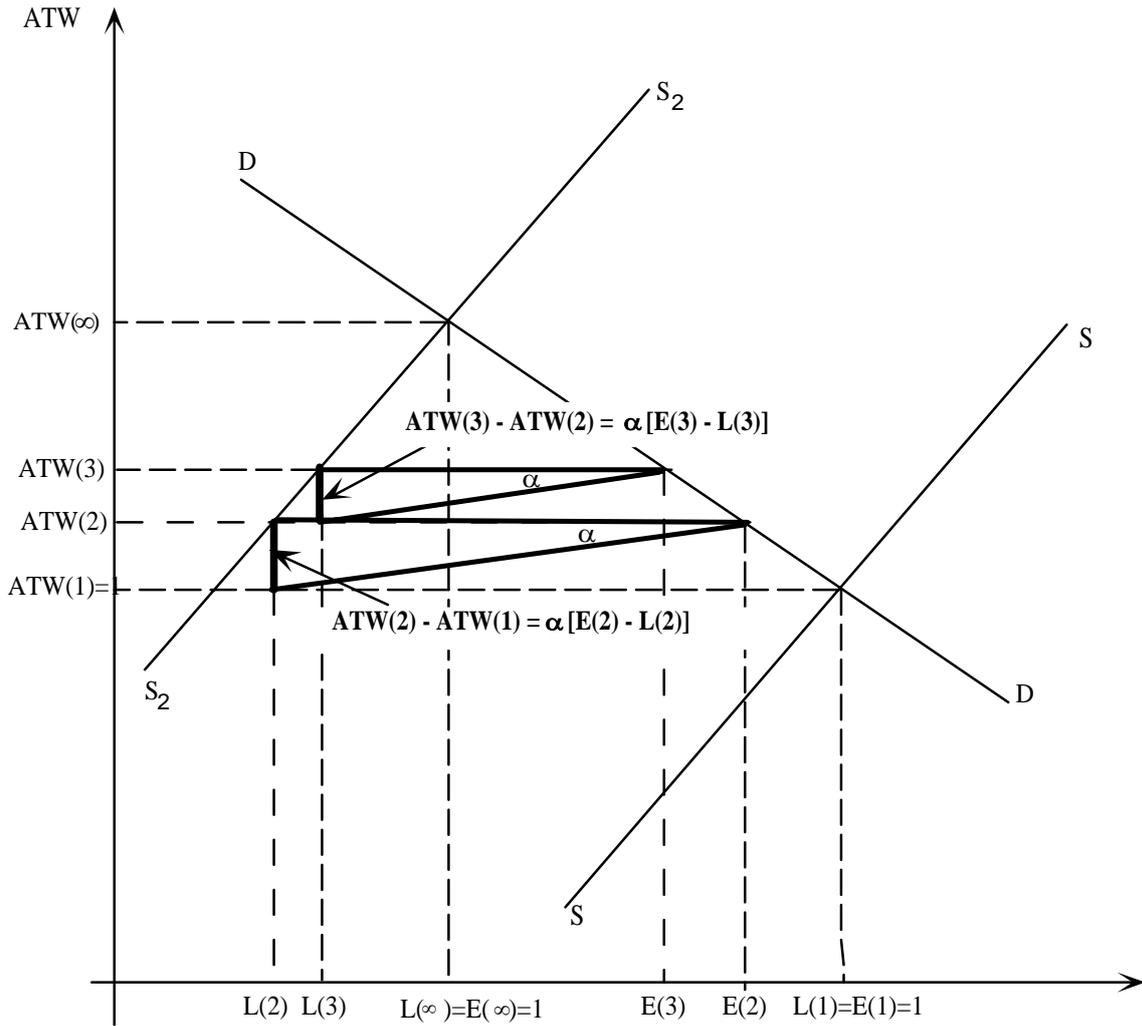
$H_t[a ; a]$ is employment of people in category a in activity a.

The flow of people from category c to U.S. employment activity a, $a \neq c$, is modelled as being proportional to the vacancies in a and to the share of category c in the supply of labor to activity a from people outside category a. Thus, if people in category c account for 10 per cent of the people outside category a who want jobs in employment-activity a, then people in category c fill 10 per cent of the vacancies in a. That is,

$$H_t(c ; a) = V_t(a) * \left[\frac{L_t(c;a)}{\sum_{s \neq a} L_t(s;a)} \right],$$

for all categories $c \neq a$ and all U.S. employment activities a. (3.24)

Figure 3.3. Wage adjustment in a steady state with one type of employment: a supply shock



In this illustration, but not in USAGE-M, we assume that there is only one type of labor and that the basecase was generated under steady-state assumptions in which technology, consumer tastes, foreign prices, capital availability, taxes, the size of the labor force and other variables affecting the demand for and supply of labor are unchanged from year to year. In this steady state the demand curve for labor (drawn for a given tax rate) is DD and the supply curve is SS. For convenience we assume that the after-tax wage rate, employment and the supply of labor are one in the steady state, allowing us to eliminate the basecase forecasts from equation (3.21). Now consider a policy simulation (e.g. a decrease in migrant inflow) involving a shift in the supply curve in year 2 to S_2S_2 , where it remains for all future years. Assuming that there is no change in tax rates (so that changes in after-tax wage rates on the vertical axis are also changes in pre-tax wage rates), then employment decreases from $E(1)$ to $E(2)$ to ... $E(\infty)$, labor supply decreases from $L(1)$ to $L(2)$ and then rises from $L(2)$ to $L(3)$ to ... $L(\infty)$, and wages rise from $ATW(1)$ to $ATW(2)$ to ... $ATW(\infty)$.

In (3.24), we assume that there is always competition for jobs, that is we assume that the number of people from outside category a who plan to work in employment-activity a , $\sum_{s \neq a} L_t(s; a)$, is greater or equal to the number of vacancies $[V_t(a)]$ in a .⁸ This ensures that $H_t(c; a)$ is less than or equal to $L_t(c; a)$ for all categories $c \neq a$ and all U.S. employment activities a .

⁸ While this condition is not guaranteed by the equations in Table 3.1, it was in fact satisfied in our applications in sections 4 and 5.

Figure 3.4. Specifying the flows from categories to activities

| Activities Categories | Employment in U.S. occupation | Unemployed in U.S. | Employed in Mexico |
|----------------------------------|----------------------------------|-----------------------|-----------------------|
| Employment in U.S. occupation | 1 | 2 | 5 |
| Unemployed in U.S. | 1 | 3 | 5 |
| Employed in Mexico | 1 | zero | 5 |
| New entrant | 1 | 4 | 4 |

A familiar idea in labor economics is that unemployed people, especially long-term unemployed people, have a lower probability of filling vacancies than employed people wanting to move. This idea could be handled in (3.24) by attaching weights to the L 's appearing on the RHS. We achieve a similar effect by assuming that the unemployed, especially the long-term unemployed, make comparatively weak offers to employment. [Recall the last two dot points in our discussion of the $B_t(c;a)$'s.] That is, $\sum_{a \in \text{U.S. employ activ}} L_t(c;a) / \text{CAT}_t(c)$ is low for people in unemployment categories c .

The number of incumbents in employment-category c who remain in activity c [$H_t(c;c)$] is defined as the number of people in category c less the number who move out of activity c :

$$H_t(c;c) = \text{CAT}_t(c) - \sum_{a \neq c} H_t(c;a) \quad , \text{ for all employment categories } c \text{ (including Mexico)} \quad (3.25)$$

With [$H_t(c;a)$] being less than or equal to [$L_t(c;a)$] for $a \neq c$, $H_t(c;c)$ is greater than or equal to $L_t(c;c)$. People in employment-category c who planned to work in activity $a \neq c$ but who are unable to move to a due to insufficient vacancies simply remain in c .

Flows from all U.S. employment categories to U.S. unemployment activities (area 2 in Figure 3.4)

People in a U.S. employment category at the start of year t cannot move to a long-run unemployment activity. If they move into unemployment it must be to short-run unemployment. The number of people who make the move to short-run unemployment is the sum of two parts: voluntary moves, $L_t(c;u)$, and involuntary moves. We model involuntary moves from U.S. employment category c as a fraction, $\mu(c)$, of the number of people in the category:

$$H_t(c;u) = \begin{cases} L_c(c;u) + \mu(c) * \text{CAT}_t(c) & \text{for short - run unemployment activities } u \\ 0 & \text{for long - run unemployment activities } u \end{cases} \quad , \text{ for all U.S. employment categories } c \quad (3.26)$$

Normally, $\mu(c)$ is exogenous. However, it is possible that (3.26) in conjunction with (3.24) will give values for $H_t(c;c)$ in (3.25) that exceed $E_t(c)$. In this case, $V_t(c)$ would be negative. We avoid this situation by treating $\mu(c)$ as an endogenous variable. If $V_t(c)$ is greater than zero, then $\mu(c)$ equals an exogenously given minimum value determined by the rate at which individuals are dismissed because of their performance or other factors unrelated to overall demand for people in activity c . Alternatively, $\mu(c)$ moves sufficiently above its minimal value to ensure that $V_t(c)$ equals zero. When $\mu(c)$ is above its minimum value, then there are involuntary flows from employment category c to unemployment caused by overall shortage of jobs.

Flows from U.S. unemployment categories to U.S. unemployment activities (area 3 in Figure 3.4)

Next we deal with flows between unemployment categories and unemployment activities. We ensure that short-term unemployed people who fail to obtain a job flow to long-term unemployment; and that long-term unemployed people who fail to obtain a job remain in long-term unemployment:

$$H_t(c;u) = \begin{cases} 0 & \text{for short - run unemployment activities } u \\ CAT_t(c) - \sum_{a \in \text{employment activ}} H_t(c;a) & \text{for long - run unemployment activities } u \end{cases}$$

for all U.S. unemployment categories c and all unemployment activities u . (3.27)

Flows from New categories to U.S. unemployment activities or to Mexico (area 4 in Figure 3.4)

New legal entrants (either domestic or foreign) who fail to get a U.S. job are allocated to a short-run unemployment activity. New illegal entrants who fail to get a U.S. job are allocated to employment in Mexico. These allocations are specified by:

$$H_t(c;u) = \begin{cases} CAT_t(c) - \sum_{a \in \text{U.S. employ activ}} H_t(c;a) & \text{for } c \text{ not foreign, illegal and for short - run unemploy activ } u \\ CAT_t(c) - \sum_{a \in \text{U.S. employ activ}} H_t(c;a) & \text{for } c \text{ foreign, illegal and for Mexican activities } u \\ 0 & \text{otherwise} \end{cases}$$

for all New categories c and all unemployment or Mexican activities u . (3.28)

Flows from non-New categories to Mexico (area 5 in Figure 3.4)

We assume that flows to Mexico from non-Mexican, non-New categories are voluntary. This means that foreign illegal workers in the U.S. can go home if they want to. Finally, the flow from the category of working in Mexico to the activity of working in Mexico is determined as the number of people in the category less the number that obtain jobs in the U.S. Thus we have:

$$H_t(c;u) = \begin{cases} L_t(c;u) & \text{for } c \text{ non - Mexican} \\ CAT_t(c) - \sum_{a \in \text{U.S. employ activ}} H_t(c;a) & \text{for } c \text{ Mexican} \end{cases}$$

for all non-New categories c and for Mexican activities u (3.29)

Completing the link from categories to activities

To complete the link from categories at the start of year t to activities in year t we include the equation:

$$\sum_c H_t(c, a) = E_t(a) \quad , \text{ for all U.S. unemployment activities and Mexican activities } a \quad (3.30)$$

A similar equation is not required for U.S. employment activities. Such an equation is implied by (3.23) and (3.24).

4. Restricting the supply of foreign-illegal labor to the U.S.

In this section we use USAGE-M to compute the effects on the U.S. economy of a policy of tighter border security that raises the costs to illegal migrants of entering the U.S. The policy shock is introduced as a 25 per cent reduction in the marginal utility to potential illegal migrants from earning money in the U.S. We refer to the simulation as simulation SR (Supply Restriction).

From the point of view of supply decisions by potential illegal migrants, the policy shock is equivalent to a 25 per cent reduction in the wage that they anticipate receiving in the U.S. if they make a successful entry. Another way to think about the policy shock is as an increase in the difficulties faced by smugglers in organizing illegal border crossings.⁹ This could be expected to increase smugglers' fees. These fees currently average about \$4,000 per illegal migrant. For a potential illegal migrant who plans to stay in the U.S. for one year and who anticipates earning \$20,000, the policy shock is equivalent to an increase smugglers' fees to about \$9,000 (an increase of \$5,000 or 25% of \$20,000).

In terms of equation (3.8) in section 3, the shocks in the policy run are a 25 per cent reduction in $B_t(c;a)$ for $c = (\text{foreign, illegal, Mexico or New})$ and $a = (\text{foreign, illegal, } o)$ where o is any U.S. occupation. The shocks are introduced as 13.4 per cent reductions in both 2006 and 2007.

4.1. Net and gross flows of illegal migrants into U.S. employment

Chart 4.1 shows the employment paths for illegal migrants in the basecase and the policy runs. In the basecase (without the policy shocks), employment of illegal migrants grows between 2005 and 2019 at 3.8 per cent a year, from 7.3 million to 12.4 million. By contrast, the employment of legal residents through this period grows by only 1.0 per cent a year. The share of illegal migrants in total employment increases from 4.98 per cent in 2005 to 7.17 per cent in 2019. Because illegal migrants have low-paid jobs, their share in the total wagebill is considerably less than their share in total employment. In our basecase, their wagebill share goes from 2.69 per cent in 2005 to 3.64 per cent in 2019.

In creating the basecase, we recognised that population growth in Mexico is slowing and that, in the absence of fresh U.S. policy initiatives, growth in net inflow of illegal migrants is likely to be quite moderate over the next 15 years.¹⁰ We assume average annual growth of net inflow of illegal migrants to U.S. employment of one per cent. Nevertheless, the number of illegal migrants in the U.S. will grow rapidly. This is because the current net inflow to U.S. employment (about 400,000) is high relative to the stock of illegal migrants in U.S. employment (7.3 million). Thus, even with only slow growth (1%) in net inflow, or even no growth, strong growth in foreign-illegal employment is assured.

⁹ This way of viewing the policy shock was suggested to us by Gordon Hanson.

¹⁰ This view is partially supported by Hanson and McIntosh (2007) who emphasise the link between Mexican population growth and net inflow of migrants to the U.S. Against this, they also point out that network effects are important. The current large Mexican population in the U.S. will encourage further inflow by providing a support network in the U.S. for potential new migrants.

Chart 4.1. Employment of foreign illegals (millions) in the SR simulation

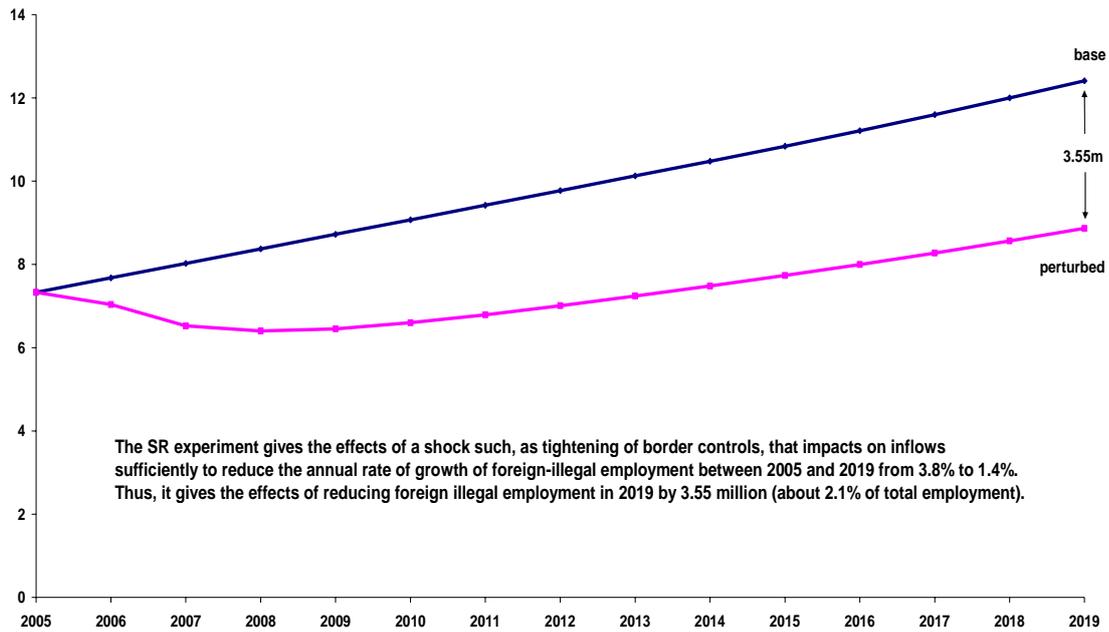
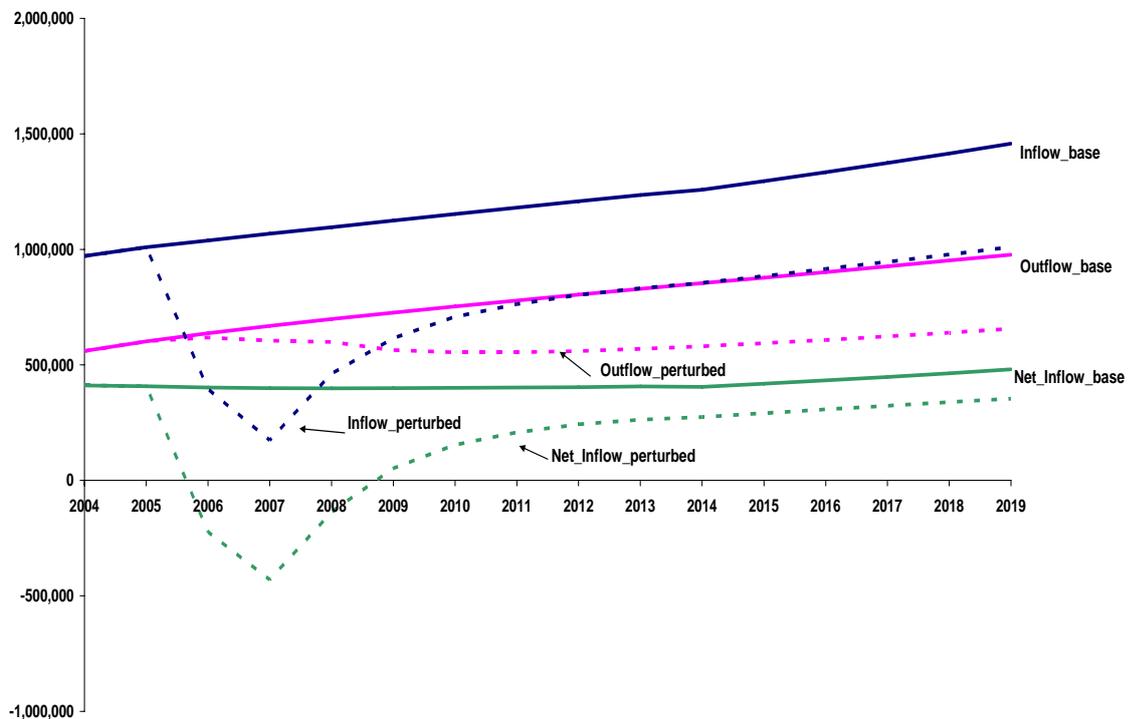


Chart 4.2. Flows of illegal migrants in the SR simulation



In the policy run, foreign illegal employment grows between 2005 and 2019 at 1.4 per cent a year, from 7.3 million to 8.9 million. Thus the policy has the effect of reducing foreign-illegal employment in 2019 by 3.55 million (=12.4 – 8.9) or 28.6 per cent.

Chart 4.2 shows that the policy of tighter border security affects flows of illegal migrants in both directions. The shocks have a direct effect on inflows by reducing the number of people in Mexico who want to move illegally to the U.S. Via (3.8) there is a reduction in $L_i(c;a)$ for $c = (\text{foreign, illegal, Mexico or New})$ and $a = (\text{foreign, illegal, o})$ where o is any U.S. occupation. The shocks have an indirect effect on outflows by lowering the number of illegal migrants present in the U.S. and thereby lowering the number who seek to go home. In terms of our model, the shocks reduce the number of people in those categories in the U.S. that offer to supply labor to Mexico, that is, the shocks reduce the number of people in $CAT_i(c)$ where c is a foreign-illegal category in the U.S.

There are two features of Chart 4.2 that require further comment. First, it implies that the net inflow to the U.S. workforce of foreign illegals of about 400,000 in 2005 was generated by a gross inflow of about 1 million and a gross outflow of about 600,000. These numbers are consistent with foreign illegal migrants making frequent trips home. However, there are no firm data on gross flows. Fortunately we have found that our results for the effects of reducing foreign-illegal employment in the U.S. are not sensitive to our assumptions concerning the initial levels of gross flows.

The second notable feature of Chart 4.2 is the sharp decline in the early years of the policy run in the net and gross inflows of foreign illegals to U.S. employment, followed by recovery in later years. It appears that increased border security would have a much greater effect on flows of illegal migrants in the short run than in the long run.

To explain this result we start with (3.8). This equation suggests that the initial impact of the policy shocks is a 44% decline in supply from Mexico.¹¹ However, the policy-induced decline in gross inflow shown in Chart 4.2 for 2007 is 84 per cent and the net inflow in the policy run is negative. The impact decline (44 per cent) in supply from Mexico causes an increase in foreign-illegal wages (equation 3.21) and a decrease in U.S. demand for foreign-illegal labor (equation 3.16): the growth rate in demand for foreign-illegal labor for the period 2005 to 2007 turns from strongly positive in the basecase to negative in the policy run. Because the *level* of net inflow of foreign illegals depends on U.S. *growth* in demand for their services, negative growth in this demand translates into negative net inflow requiring a dramatic reduction in gross inflow. Eventually, wages of foreign-illegal workers in the U.S. rise sufficiently in the policy run to reconcile demand with reduced supply from Mexico. At this stage, demand in the policy run recommences growth at approximately the same rate as in the basecase. This allows net and gross inflow of foreign illegals to partially recover. In 2019 net inflow in the policy run is 27 per cent less than in the basecase and gross inflow is 31 per cent less.

An effect of tighter border security noted in the literature¹², but not built into the SR policy run, is that it reduces the preference of foreign illegals in the U.S. for returning to Mexico voluntarily. The argument is that with tighter security, illegal migrants contemplating a trip home realize that it will be more difficult to return to the U.S. We

¹¹ In this equation, $-\eta/(1+\eta)$ has the value 2. Where c is a Mexican category and a is a U.S. activity, a 25 per cent reduction in $B_i(c;a)$ generates reduction in $L_i(c;a)$ of approximately 44 per cent [=100*((1-0.25)²-1)]. We can ignore the change in the denominator on the RHS of (3.8) because offers to the U.S. are a relatively small part of total labor supply from Mexico.

¹² See, for example, Angelucci (2003).

investigated this effect by introducing additional shocks in the SR policy run that reduced the preference of foreign illegals in the U.S. to return home by 20 per cent [that is, we introduced 20 per cent reductions in $B_i(c;a)$ for $c = (\text{foreign, illegal, U.S. employment or unemployment})$ and $a = (\text{foreign, illegal, Mexico})$]. The additional shocks had little effect on our results. The reason can be seen in Chart 4.3. Reducing the outflow preference for foreign illegals has almost no long-run effect on net inflow. The cut in voluntary outflow reduces vacancies for foreign illegal workers in the U.S., thereby causing an equivalent cut in inflow.

4.2. Macroeconomic effects of reducing the supply of illegal migrants

Charts 4.4 and 4.5 show the effects of the supply-reducing policy on macroeconomic variables in the U.S. Each effect is expressed as a percentage deviation from the basecase.

Chart 4.4 shows that the policy causes a long-run reduction in U.S. employment. In 2019, the number of jobs is 2.2 per cent lower in the policy run than in the basecase. This mainly reflects the reduction of 3.55 million in the number of foreign illegal jobs: 3.55 million is 2.1 per cent of the number of U.S. jobs in 2019 in the basecase. There is also a small loss of legal jobs, discussed in subsection 4.5.

Because the lost jobs are mainly for low-paid workers, the reduction in labor input in 2019 is less than 2.2 per cent. Labor input is measured in hours weighted by wage rates to reflect differences in the productivities of workers. Measured this way, we might expect the percentage loss in labor input to be about 28.6 per cent (the reduction in foreign-illegal employment) of 3.64 per cent (the illegal share in the basecase U.S. wagebill for 2019). This is only 1.04 per cent ($=0.286*3.64$). However, restriction of foreign-illegal employment shifts the occupational composition of remaining employment towards low-paid occupations, expanding the loss in labor input in 2019 to about 1.6 per cent. The implications of the shift in the occupational mix of the remaining employment for the welfare of legal residents are explained in subsection 4.6 (factor 2).

The long-run reduction in the capital stock of the U.S. approximately matches that of the labor input. As mentioned in section 2, we assume that the policy does not change either long-run rates of return or technologies, implying that it has little effect on the K/L ratio.

With labor and capital down by about 1.6 per cent and no change in technology, the long-run reduction in GDP is also about 1.6 per cent. This reduces average annual growth in GDP for the period 2005 to 2019 from 3.03 per cent in the basecase to 2.92 per cent in the policy run.

In Chart 4.5 the long-run percentage effects on C, I, G, X and M are all negative and ranged around that for GDP. Public consumption (G) falls relative to private consumption (C) because consumption of public goods by foreign illegals is high relative to their consumption of private goods.¹³ Investment (I) falls relative to GDP mainly because even by 2019, the capital stock is not fully adjusted and is still falling slightly relative to the basecase. C plus G rises relative to GDP because the policy improves the U.S. terms of trade (the price of exports divided by the price of imports). This is a benefit from having a smaller economy. With a smaller economy, the long-run deviation for exports is negative (Chart 4.4). With no shock to foreign-demand curves for U.S. exports, the cut in export volumes is accompanied by an increase in their foreign-currency prices. On the import side

¹³ In the basecase for 2019, foreign illegals account for 3.7 per cent of public consumption (see subsection 4.6, factor 5). However, they account for only 2.4 per cent of private consumption.

Chart 4.3. Flows of illegal migrants in the SR policy run under alternative outflow preference assumptions

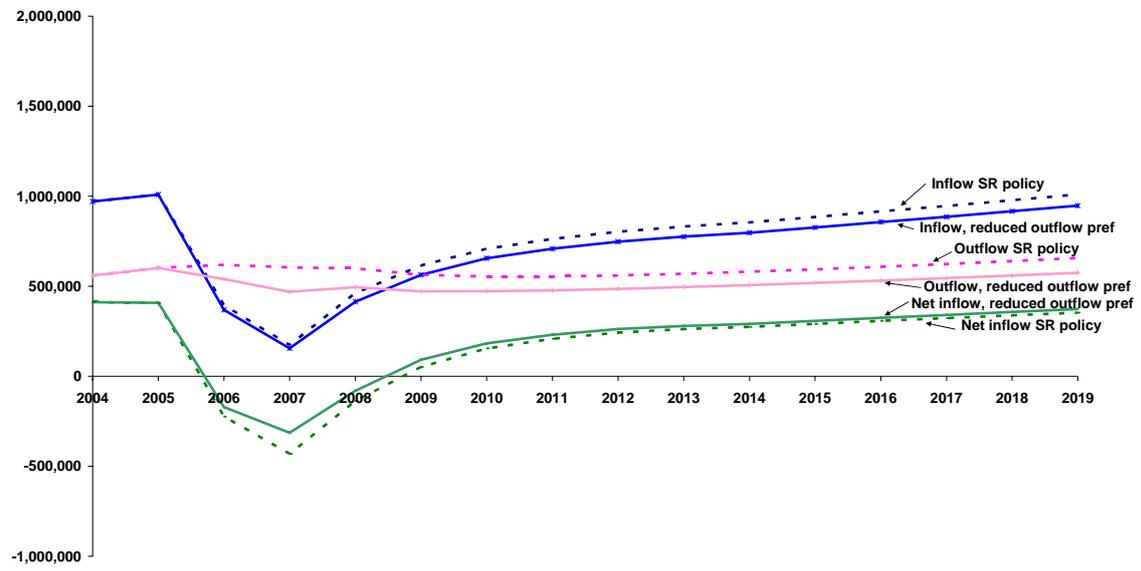
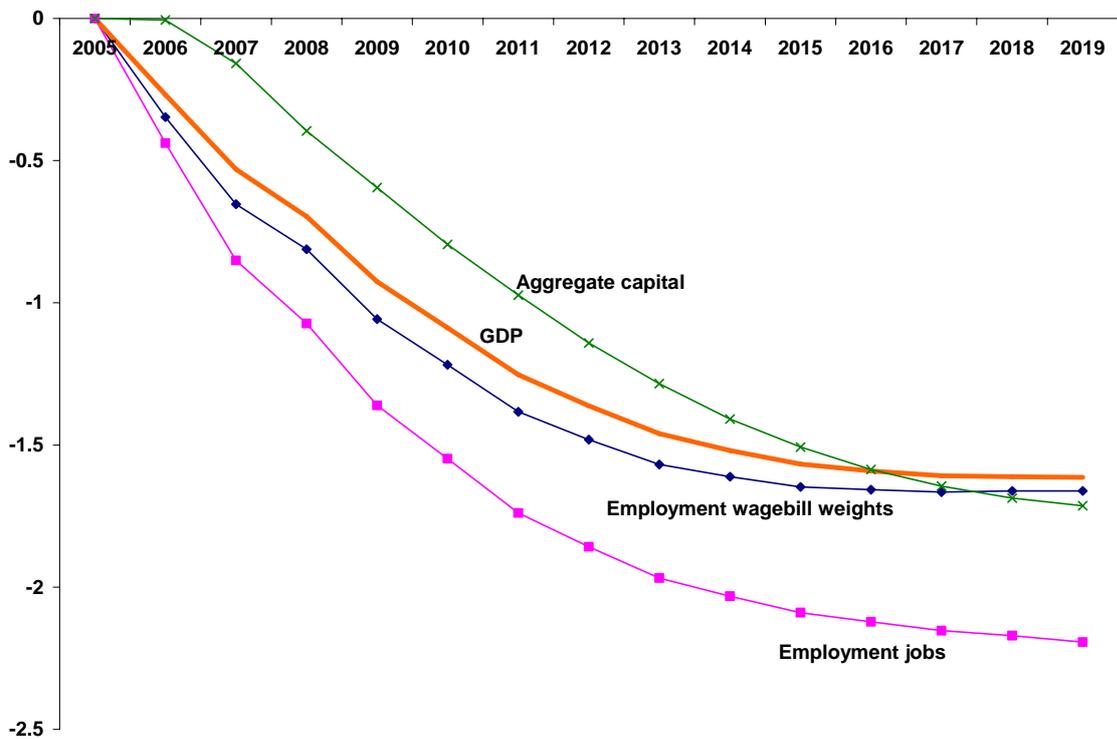
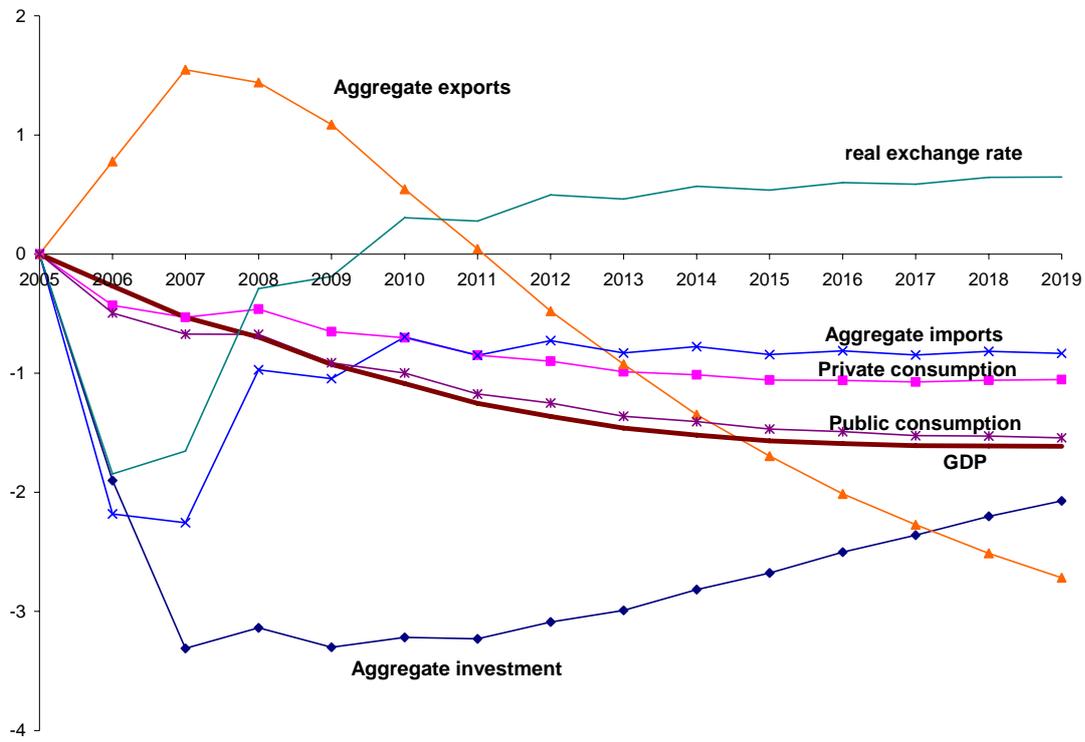


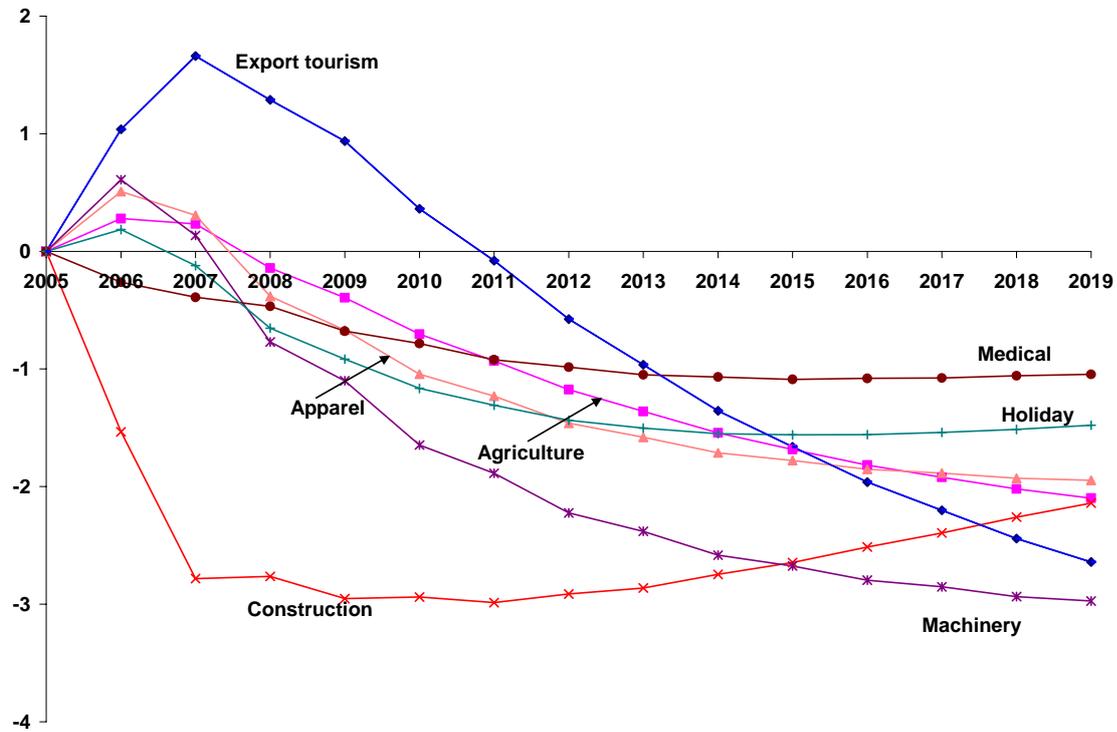
Chart 4.4. GDP, employment and capital in the SR simulation (percentage deviation from basecase)



**Chart 4.5. Expenditure aggregates in the SR simulation
(percentage deviation from basecase)**



**Chart 4.6. Selected industry outputs
(percentage deviation from basecase)**



we assume that changes in U.S. demand have no effect on foreign-currency prices. An improvement in the terms of trade allows the U.S. to increase its consumption (public and private) relative to its GDP. The increase in $C + G$ relative to GDP generates a deterioration in real trade balance ($X - M$), supported by long-run real appreciation (Chart 4.5).

The short-run results in Chart 4.5 are dominated by the need for the economy to adjust in the policy run to a lower capital stock than it had in the basecase. In the short run, the policy causes a relatively sharp reduction in investment and a consequent real devaluation. This temporarily stimulates exports and inhibits imports. As the adjustment in the capital stock is completed, investment recovers, causing the real exchange rate to rise, exports to fall and imports to rise.

4.3. Industry results

Chart 4.6 shows deviation results for outputs of representative industries. Output results can be explained largely by the macro results.

In the short run, investment-related industries, e.g. Construction, are strongly adversely affected. This reflects the adjustment of the economy to a lower capital stock which causes a sharp negative deviation in investment relative to GDP (Chart 4.5). Trade-exposed industries benefit in the short run from real devaluation associated with the weakening of the investment/GDP ratio. This applies to both export-oriented industries such as Export tourism¹⁴ and import-competing industries such as Apparel and Agriculture. In the case of the Holiday industry, the small short-run favorable effect arises from substitution by U.S. residents of domestic holidays for foreign holidays reflecting an exchange-rate-induced increase in the price of foreign holidays.

In the long-run, the SR simulation gives a positive deviation on the real exchange rate (Chart 4.5). Consequently, in Chart 4.6, trade exposed industries show output deviations that are more negative than that for GDP. The long-run deviation in Construction is also slightly more negative than that of GDP: the long-run investment deviation (Chart 4.5) is slightly below that of GDP.

A full set of long-run results (for 2019) for industry outputs is given in Table 4.1, column (5). For most industries, the output deviation is quite close to the long-run deviation in GDP (-1.61). The gaps between the GDP deviation and the output deviations for individual industries reflect changes in the long-run expenditure composition of GDP. As already mentioned, the Construction deviation (-2.14) is more negative than that of GDP because of a long-run decline in the I/GDP ratio. Similarly, other investment-oriented industries such as Machinery and Electrical Machinery show output deviations that are more negative than that of GDP. Non-trade-exposed consumption-oriented industries, mainly services, have output deviations that are less negative than that for GDP. This is explained by the long-run increase in the ratio of $C + G$ to GDP (Chart 4.4). Foreign holiday is an outlier among the long-run output results. This industry benefits from long-run exchange-rate-induced substitution of foreign holidays for domestic holidays.

An implication of our explanation (relying on macro mechanisms) of the output results in Table 4.1 is that the long-run effect on an industry's output of restrictions in illegal immigration is not closely linked to the industry's use of foreign-illegal labor. Column (3) of Table 4.1 shows the shares in 2005 of industry costs accounted for by foreign-illegal labor. When we regress the output results in column (5) against the share data in column (3), we obtain an R^2 of only 0.04.¹⁵

¹⁴ Definitions of Export tourism and other non-transparent industries are given at the foot of Table 4.1.

¹⁵ In this regression, we leave out industries 33 to 36. These industries do not employ labor.

Table 4.1. Data for 2005 on labor costs as percentages of industry costs and percentage deviation results for 2019 in simulation SR

| Industry | Data for 2005, percentage shares in costs | | | | SR simulation: Percentage deviations in 2019 | | |
|--------------------------|---|-------------------------|---------------------------|--------------|--|-----------------------|--------------|
| | Domestic (1) | Foreign legal (2) | Foreign illegal (3) | Total (4) | Output (5) | Labor input (6) | Jobs (7) |
| 1 Agriculture | 13.61 | 0.57 | 0.59 | 14.78 | -2.10 | -2.17 | -3.26 |
| 2 Ground maintenance | 45.63 | 4.81 | 4.08 | 54.52 | -1.71 | -2.19 | -3.70 |
| 3 Mining | 21.72 | 1.79 | 0.55 | 24.05 | -2.18 | -2.23 | -2.61 |
| 4 Construction | 42.37 | 3.62 | 4.51 | 50.50 | -2.14 | -2.12 | -3.30 |
| 5 Dairy & sugar manu. | 9.76 | 1.12 | 0.76 | 11.64 | -1.57 | -1.60 | -2.62 |
| 6 Other food manu. | 13.73 | 1.70 | 1.39 | 16.83 | -1.81 | -1.94 | -3.18 |
| 7 Tobacco products | 14.65 | 1.55 | 0.89 | 17.09 | -1.54 | -1.61 | -2.58 |
| 8 Apparel | 11.81 | 2.31 | 1.34 | 15.47 | -1.95 | -2.00 | -3.32 |
| 9 Textiles | 19.48 | 2.42 | 1.50 | 23.40 | -2.38 | -2.69 | -3.67 |
| 10 Wood & furniture | 25.78 | 2.48 | 1.82 | 30.08 | -2.71 | -2.72 | -3.57 |
| 11 Paper & publishing | 28.79 | 3.28 | 0.76 | 32.84 | -2.10 | -2.11 | -2.58 |
| 12 Chemicals | 18.49 | 2.22 | 0.53 | 21.25 | -2.02 | -3.71 | -4.22 |
| 13 Petroleum products | 4.00 | 0.38 | 0.10 | 4.47 | -1.53 | -1.04 | -1.43 |
| 14 Footwear | 16.96 | 3.09 | 1.45 | 21.50 | -2.14 | -2.18 | -3.17 |
| 15 Metal products | 24.30 | 2.57 | 1.00 | 27.87 | -2.87 | -2.94 | -3.52 |
| 16 Machinery | 28.28 | 3.33 | 0.76 | 32.38 | -2.97 | -3.01 | -3.43 |
| 17 Computers | 6.12 | 1.21 | 0.07 | 7.40 | -1.69 | -1.62 | -1.84 |
| 18 Electrical machinery | 18.47 | 2.93 | 0.49 | 21.89 | -2.63 | -2.71 | -3.15 |
| 19 Motor vehicles | 14.78 | 1.81 | 0.71 | 17.30 | -2.60 | -2.61 | -3.25 |
| 20 Transport equipment | 24.52 | 3.27 | 0.60 | 28.39 | -2.25 | -2.23 | -2.64 |
| 21 Manufacturing nec | 27.34 | 3.48 | 1.08 | 31.90 | -2.54 | -2.61 | -3.21 |
| 22 Communication | 16.10 | 1.67 | 0.15 | 17.92 | -1.52 | -1.50 | -1.63 |
| 23 Utilities | 9.09 | 0.78 | 0.27 | 10.14 | -1.19 | -0.94 | -1.38 |
| 24 Wholesale & retail | 41.57 | 4.19 | 1.17 | 46.93 | -1.54 | -1.51 | -2.01 |
| 25 Housing services | 9.26 | 1.00 | 0.15 | 10.41 | -1.68 | -1.54 | -1.92 |
| 26 Business & fin. serv. | 47.73 | 5.05 | 0.29 | 53.08 | -1.65 | -1.62 | -1.73 |
| 27 Medical services | 53.90 | 6.62 | 0.45 | 60.97 | -1.05 | -0.90 | -1.15 |
| 28 Education | 45.66 | 5.49 | 0.24 | 51.40 | -1.58 | -1.50 | -1.64 |
| 29 Social services | 51.97 | 5.27 | 0.79 | 58.02 | -1.17 | -1.16 | -1.57 |
| 30 Govt. enterprise | 29.61 | 3.31 | 0.32 | 33.24 | -1.24 | -1.26 | -1.49 |
| 31 Other priv. services | 47.43 | 5.68 | 1.98 | 55.09 | -1.63 | -1.68 | -2.48 |
| 32 Govt. services | 48.84 | 4.49 | 0.36 | 53.70 | -1.54 | -1.52 | -1.72 |
| 33 Holiday* | 0.00 | 0.00 | 0.00 | 0.00 | -1.48 | — | — |
| 34 Foreign holiday* | 0.00 | 0.00 | 0.00 | 0.00 | 1.68 | — | — |
| 35 Export tourism* | 0.00 | 0.00 | 0.00 | 0.00 | -2.64 | — | — |
| 36 Other non-resident* | 0.00 | 0.00 | 0.00 | 0.00 | -1.46 | — | — |
| 37 Transport margins | 29.29 | 2.71 | 0.89 | 32.90 | -1.93 | -1.95 | -2.43 |
| 38 Auto rental | 21.70 | 2.42 | 0.84 | 24.96 | -1.70 | -1.69 | -2.28 |
| Total | 33.72 | 3.59 | 1.00 | 38.31 | | -1.66 | -2.19 |

* In USAGE-M, the Holiday industry is a collection of inputs such as hotels and airline travel that are used by U.S. residents when they take a holiday in the U.S. Foreign holiday is a collection of inputs such as airline travel and shopping in foreign countries that are used by U.S. residents when they take a holiday outside the U.S. Export tourism is a collection of inputs used by foreign tourists when they take a holiday in the U.S. Other non-resident is a collection of inputs purchased in the U.S. by diplomats, World-Bank officials etc. None of these artificial industries employs people directly.

Columns (6) and (7) of Table 4.1 give long-run results for deviations in labor input and jobs by industry. As mentioned earlier, labor input is a wage weighted measure and shows smaller negative deviations than those for jobs. The regression of the labor-input deviations in column (6) against the foreign-illegal share data in column (3) again gives a low R^2 , 0.06. This confirms our finding that the long-run industry effects of restricting illegal migration are not closely associated with current levels of reliance by industries on illegal labor.

When we regress the jobs results in column (7) against the share data in column (3) we obtain an R^2 of 0.27. This higher R^2 reflects replacement of foreign-illegal labor with legal labor in industries that currently rely relatively heavily on foreign-illegal labor. Foreign-illegal workers in any occupation receive lower wages than legal workers in the same occupation. We assume that this means that foreign illegal workers have lower productivity than legal workers. Consequently, when we simulate the effects of restricting the supply of illegal workers, we find that job numbers fall relatively sharply in those industries in which there is a significant replacement of low-productivity illegal workers with higher-productivity legal workers.

4.4. Occupational employment and wage effects for legal U.S. workers

The last two column in Table 4.2 shows the long-run effects of the supply-restriction policy on employment and real wage rates (wage rates deflated by the consumer price index) of legal U.S. residents by occupation. The first three columns of numbers show shares of domestic-legal, foreign-legal and foreign-illegal workers in occupational labor costs to U.S. industries.

At first glance, it may seem surprising that the occupational employment results, which are almost entirely positive, are consistent with a negative overall outcome. As can be seen from the last row of Table 4.2, total employment of legal U.S. residents falls by 0.16 per cent. This is explained in subsection 4.5. Here, we reconcile the negative overall employment effect with positive effects for most occupations.

Recall that the occupational classification was chosen to give maximum detail on the employment of illegal migrants. Consequently, most of the occupations in Table 4.2 are those in which illegal migrants are strongly represented. These are the occupations in which legal residents would gain jobs if greater restrictions were enforced on the supply of illegal migrants. Sixty per cent of U.S. legal employment is in the catch-all occupation Services other. This occupation shows a negative result, -1.27, in Table 4.2.

In broad terms, the occupational employment results in Table 4.2 show a long-run transfer of U.S. legal employment from Services other (an occupation that employs almost no foreign illegals) to the occupations that currently employ large numbers of illegal migrants. The regression equation of employment deviations in the second last column of Table 4.2 against the foreign-illegal shares in the third last column gives an R^2 of 0.998.

Chart 4.7 shows deviation results for legal employment in selected occupations for the full simulation period. The influence of macroeconomic factors can be seen in the deviation paths for Construction supervisors and Retail sales. Despite replacement of illegal workers by legal workers in these two occupations, the employment deviations for legal workers are negative throughout the simulation period, reflecting the negative deviations in investment and consumption (Chart 4.4).

Table 4.2. Data for 2005 on percentage shares in occupational labor costs and percentage deviation results for 2019 for legal employment and real wage rates in simulation SR

| | Data for 2005, % shares of total labor costs | | | % deviation in 2019 | |
|--------------------------------|--|---------------|-----------------|---------------------|------------|
| | Domestic | Foreign legal | Foreign illegal | Legal jobs | Legal wage |
| 1 Cooks | 73.9 | 10.5 | 15.6 | 4.20 | 1.89 |
| 2 Grounds maintenance | 67.1 | 8.1 | 24.8 | 7.45 | 3.19 |
| 3 House keeping & cleaning | 58.8 | 19.2 | 22.0 | 6.56 | 2.82 |
| 4 Janitor & building cleaner | 77.8 | 11.8 | 10.4 | 2.31 | 1.19 |
| 5 Misc. agriculture worker | 56.9 | 8.8 | 34.3 | 10.70 | 4.55 |
| 6 Construction laborer | 68.6 | 7.5 | 23.9 | 7.10 | 3.16 |
| 7 Transport packer | 61.0 | 14.4 | 24.6 | 7.37 | 3.19 |
| 8 Carpenter | 78.2 | 6.7 | 15.1 | 3.90 | 1.92 |
| 9 Transport laborer | 87.5 | 5.3 | 7.2 | 1.09 | 0.71 |
| 10 Cashier | 86.5 | 8.9 | 4.7 | 0.31 | 0.43 |
| 11 Food serving | 87.9 | 5.7 | 6.4 | 0.88 | 0.62 |
| 12 Transport driver | 87.9 | 8.1 | 4.0 | -0.09 | 0.25 |
| 13 Waiter | 86.6 | 7.6 | 5.7 | 0.64 | 0.53 |
| 14 Production, misc. assistant | 80.0 | 11.6 | 8.3 | 1.07 | 0.72 |
| 15 Food prep. worker | 77.5 | 9.2 | 13.3 | 3.42 | 1.61 |
| 16 Painter | 65.9 | 9.2 | 24.9 | 7.46 | 3.31 |
| 17 Dishwasher | 70.7 | 6.6 | 22.7 | 6.83 | 2.86 |
| 18 Construction, helper | 70.7 | 4.5 | 24.8 | 7.42 | 3.30 |
| 19 Retail sales | 89.8 | 7.9 | 2.4 | -0.50 | 0.11 |
| 20 Production, helper | 71.9 | 7.8 | 20.4 | 5.54 | 2.52 |
| 21 Packing machine oper. | 61.5 | 14.9 | 23.6 | 6.88 | 3.01 |
| 22 Butchers | 66.6 | 12.4 | 21.0 | 6.20 | 2.74 |
| 23 Stock clerk | 88.6 | 6.8 | 4.6 | 0.26 | 0.40 |
| 24 Child care | 84.8 | 10.0 | 5.2 | 0.56 | 0.51 |
| 25 Misc. food prep. | 74.0 | 11.5 | 14.5 | 3.80 | 1.74 |
| 26 Dry wall installer | 56.9 | 7.3 | 35.8 | 11.43 | 4.87 |
| 27 Nursing | 82.3 | 14.8 | 2.8 | -0.01 | 0.29 |
| 28 Industrial truck oper. | 83.2 | 8.3 | 8.5 | 1.47 | 0.87 |
| 29 Transport, cleaners | 76.1 | 8.1 | 15.8 | 4.24 | 1.93 |
| 30 Automotive repairs | 83.9 | 9.8 | 6.3 | 0.88 | 0.64 |
| 31 Sew. Machine oper. | 56.7 | 24.6 | 18.8 | 4.95 | 2.39 |
| 32 Concrete mason | 68.6 | 8.7 | 22.6 | 6.61 | 3.00 |
| 33 Roofers | 64.7 | 7.1 | 28.2 | 8.64 | 3.78 |
| 34 Plumbers | 85.9 | 6.9 | 7.1 | 1.07 | 0.80 |
| 35 Personal care | 78.4 | 15.9 | 5.7 | 0.91 | 0.66 |
| 36 Shipping clerk | 84.0 | 10.8 | 5.2 | 0.35 | 0.43 |
| 37 Brick mason | 71.3 | 6.2 | 22.5 | 6.56 | 2.97 |
| 38 Carpet installer | 68.6 | 10.0 | 21.4 | 6.21 | 2.82 |
| 39 Laundry | 66.2 | 18.3 | 15.5 | 4.22 | 1.93 |
| 40 Other production workers | 79.3 | 11.6 | 9.1 | 1.57 | 0.91 |
| 41 Maintenance & repairs | 87.2 | 10.6 | 2.2 | -0.71 | -0.01 |
| 42 Repair, helper | 78.0 | 5.3 | 16.8 | 4.56 | 2.09 |
| 43 Welder | 84.1 | 9.7 | 6.2 | 0.31 | 0.41 |
| 44 Supervisor, food prep. | 86.8 | 9.9 | 3.4 | -0.20 | 0.22 |
| 45 Construction supervisors | 89.5 | 7.1 | 3.4 | -0.27 | 0.27 |
| 46 Farm-food -clean, other | 83.8 | 10.1 | 6.1 | 0.61 | 0.53 |
| 47 Construction, other | 89.0 | 5.5 | 5.5 | 0.38 | 0.49 |
| 48 Production, other | 84.7 | 10.7 | 4.6 | -0.11 | 0.21 |
| 49 Services, other | 90.1 | 9.5 | 0.4 | -1.27 | -0.13 |
| 50 Transport, other | 87.4 | 9.4 | 3.2 | -0.40 | 0.13 |
| Total | 88.0 | 9.4 | 2.6 | -0.16 | 0.27 |

Chart 4.7. Legal employment for selected occupations in the SR simulation (percentage deviation from basecase)

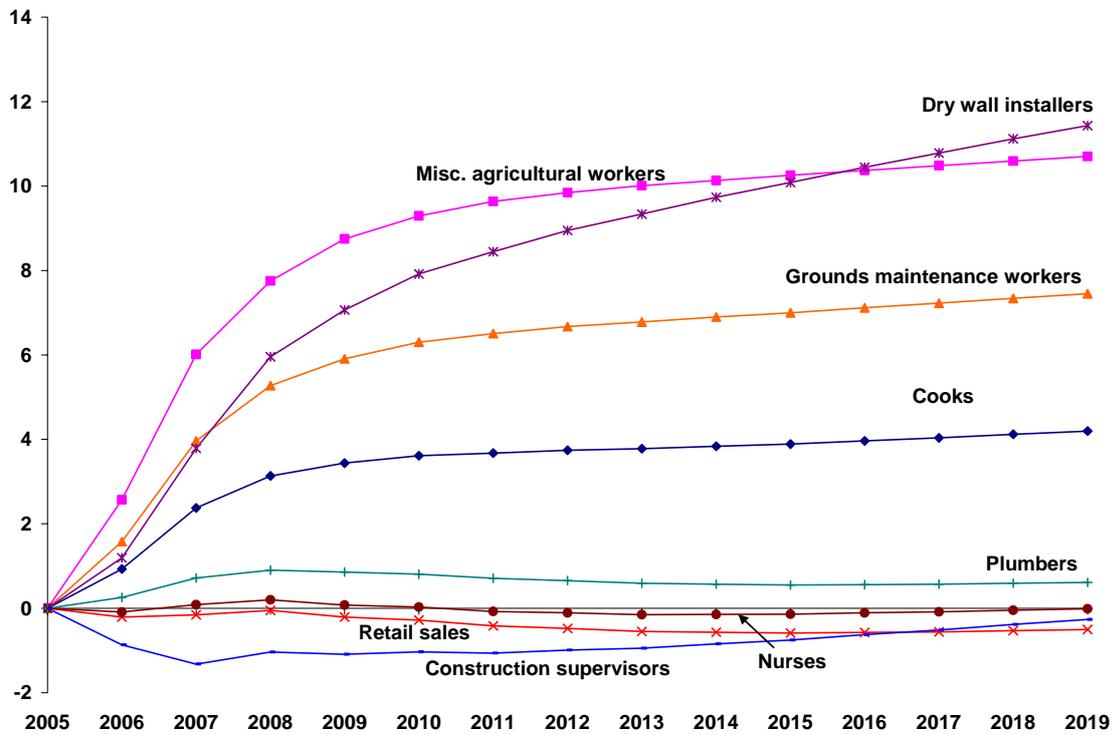
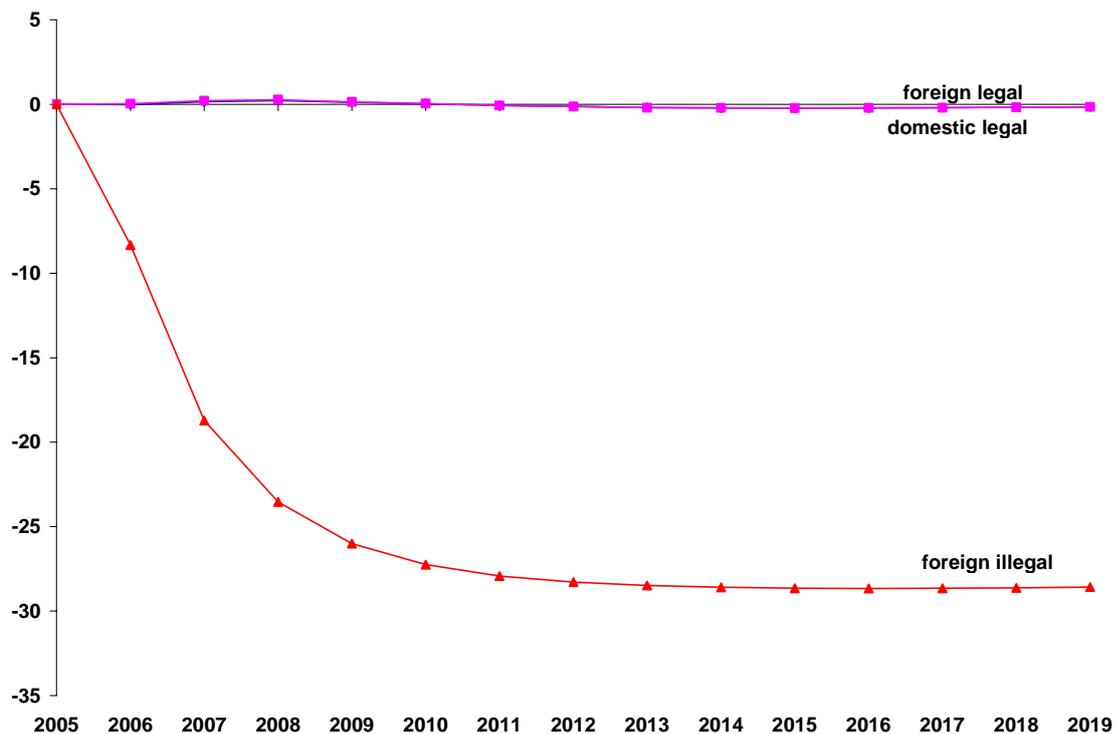


Chart 4.8. Employment by birthplace and legal status in the SR simulation (percentage deviation from basecase)



The wage results in the last column of Table 4.2 are a reflection of the employment results in the second last column. Consistent with the demand-supply theory of wage determination described in section 3, occupations that have the largest percentage increases in legal employment have the largest percentage increases in real wage rates for legal workers. When we regress the employment deviations in the second last column of Table 4.2 against the wage deviations in the last column, we obtain an R^2 of 0.999.

4.5. Wage and employment results for foreign-illegal, foreign-legal and domestic workers

Chart 4.8 shows a long-run deviation in foreign-illegal employment of -28.6 per cent (=100*3.55/12.4, Chart 4.1). By contrast, the deviations in foreign-legal and domestic employment are small: in the absence of supply shocks to the legal workforce, wage adjustments ensure that the policy of restricting foreign-illegal immigration can have no more than minor effects on long-run employment of legal U.S. residents.

To facilitate the decrease in the ratio of illegal employment to legal employment of about 28 per cent, Chart 4.9 implies that the average real occupational wage rate (using the consumer price index as the deflator) of illegal workers must rise by about 9.5 per cent. In calculating the average of 9.5 per cent, we make a weighted average of the wage rate increases for illegal workers in each of the 50 U.S. occupations, with the weights reflecting the shares of the occupations in illegal employment.

The deviations in Chart 4.9 in the average real occupational wage rate of both types of legal workers are quite small, about 0.3 per cent in the long run. We can interpret Chart 4.9 as showing that, on average, the occupational wage rates of illegal workers increase by 9.2 per cent relative to those of legal workers. Why 9.2 per cent? The most important ingredient in this result is our assumption in Figure 3.2 that the elasticity of substitution between employment of legal and illegal workers is 5. Under this assumption we would expect the ratio of the wage rate of legal workers to that of illegal workers to be related to the ratio of employment of legal to illegal workers by the back-of-the-envelope equation:

$$\frac{\text{Wage}(\text{illegal})}{\text{Wage}(\text{legal})} = \left[\frac{\text{Emp}(\text{illegal})}{\text{Emp}(\text{legal})} \right]^{-1/5} \quad (4.1)$$

This equation implies that a 28 per cent reduction in the ratio of illegal to legal employment requires an increase of 6.8 per cent in the wage of illegal workers relative to that of legal workers. With legal wages increasing by 0.3 per cent, (4.1) suggests an increase in wages for illegal workers of 7.1 per cent.

An equation similar to (4.1) applies quite accurately for each occupation in USAGE-M. However, at the aggregate level, (4.1) is only a rough guide to results in USAGE-M. An effect taken into account in USAGE-M, but not in (4.1), is that wage rates and employment for legal workers increase in occupations that heavily employ illegal workers (Table 4.2). Thus, at the aggregate level, a reduction in illegal employment of 28 per cent is associated with an increase in the average real wage rate of illegal workers (calculated as an illegal-hours-weighted average of percentage increases in illegal real wages by occupation) of more than we would expect on the basis of (4.1), 9.5 per cent instead of 7.1 per cent.

Charts 4.8 and 4.9 are drawn on scales sufficient to encompass the deviations for foreign-illegal employment and wages. However, this leaves the employment and wage deviations for foreign-legal and domestic-legal workers barely distinguishable from zero. Chart 4.10 makes these deviations visible. It shows: that the long-run deviation in employment of legal workers is negative (about -0.16 per cent for both foreign-legal and domestic workers); and that the long-run deviations in the average real occupational wage rates of foreign-legal and domestic workers are 0.38 per cent and 0.26 per cent.

Chart 4.9. Real wage rates by birthplace and legal status in the SR simulation (percentage deviation from basecase)

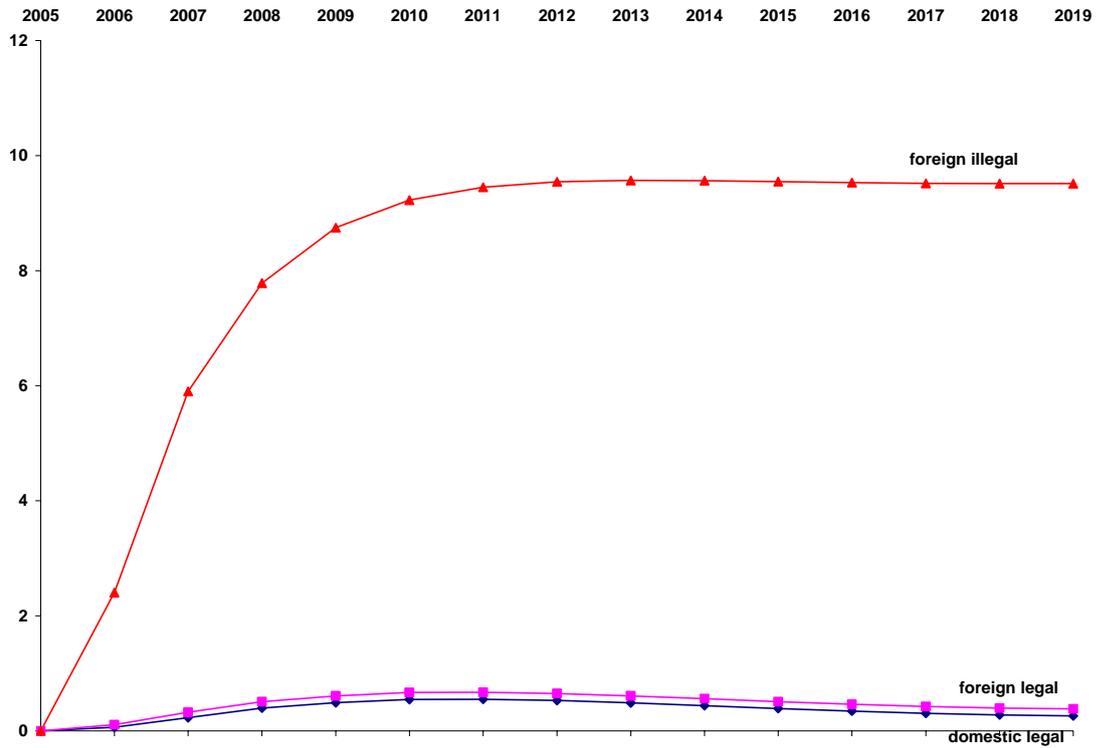
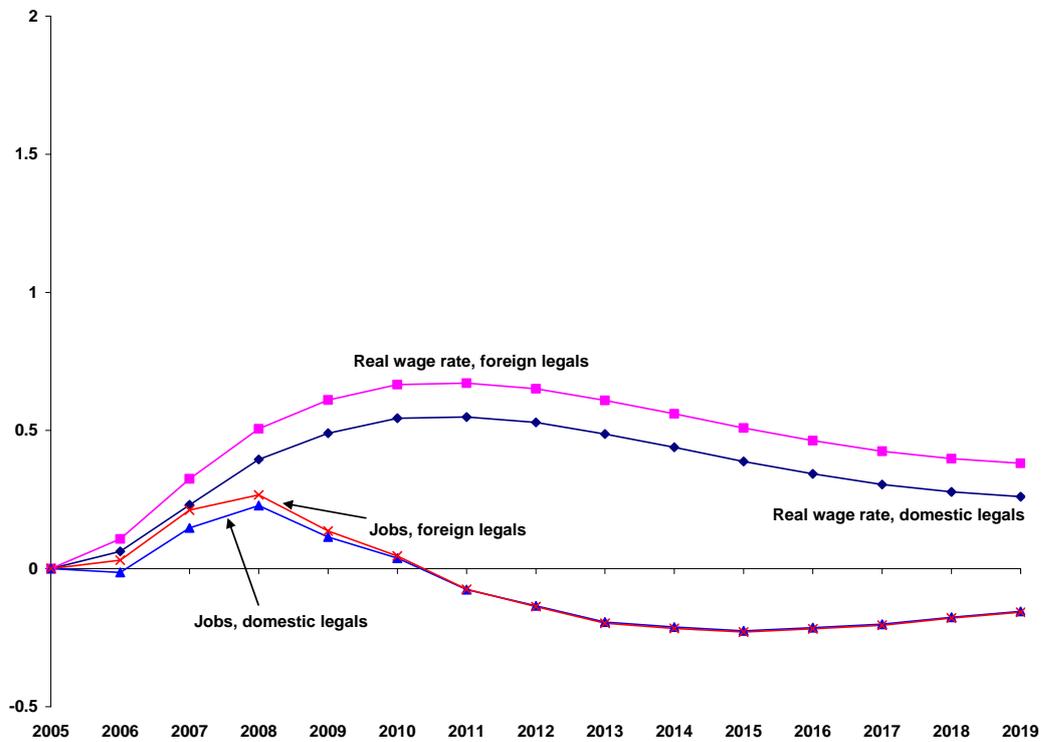


Chart 4.10. Real wage rates and employment for legal residents by birthplace in the SR simulation (percentage deviation from basecase)



In the long run, the deviations in the average real occupational wage rates of both types of legal workers are affected by two forces, one positive and one negative. The positive influence is the improvement in the terms of trade which raises the value of the marginal product of labor in terms of consumer goods. The negative influence is the increase in the legal-to-illegal employment ratio which lowers real wage rates of legal workers relative to those of illegal workers. The positive force slightly outweighs the negative force.

The deviation path in Chart 4.10 for the average real occupational wage rate of foreign-legal workers lies above that for domestic workers. Restricting illegal immigration increases the wage rates of legal workers in occupations that have a heavy foreign-illegal representation. Because the gap between the occupational profiles of foreign-legal and foreign-illegal workers is slightly narrower than that between domestic and foreign-illegal workers, restricting the supply of illegal workers slightly favors foreign-legal workers relative to domestic workers.

In the short run, Chart 4.10 shows relatively large increases in the real occupational wage rates of both types of legal workers. Wages of all workers in the U.S. are increased in the short run by the increase in the capital-labor ratio (Chart 4.4) arising from sluggish adjustment in capital.

A final aspect of Chart 4.10 worth explaining is the long-run reduction in legal employment (0.16 per cent) that occurs despite there being no supply shock to the legal workforce. We trace this to a shift in the occupational composition of legal employment towards low-skilled occupations in which there are relatively high equilibrium rates of unemployment, that is, the occupational shift is towards occupations in which relatively high rates of unemployment can be sustained with little wage pressure. This allows the deviation in aggregate employment of legal workers to be negative without producing an employment-increasing reduction in their real wage rate.¹⁶

4.6. Effects on aggregate welfare of legal U.S. residents

Chart 4.11 shows the deviation path for consumption (an amalgam of private and public) by legal U.S. residents. We interpret this as an indicator of the effect on their overall economic welfare of restricting the supply of illegal migrants.

Apart from a kink in 2007-8, corresponding to the peak in the employment deviation for legal workers (Chart 4.10), the consumption path in Chart 4.11 slopes downwards before flattening out at a long-run deviation of about -0.52 per cent.

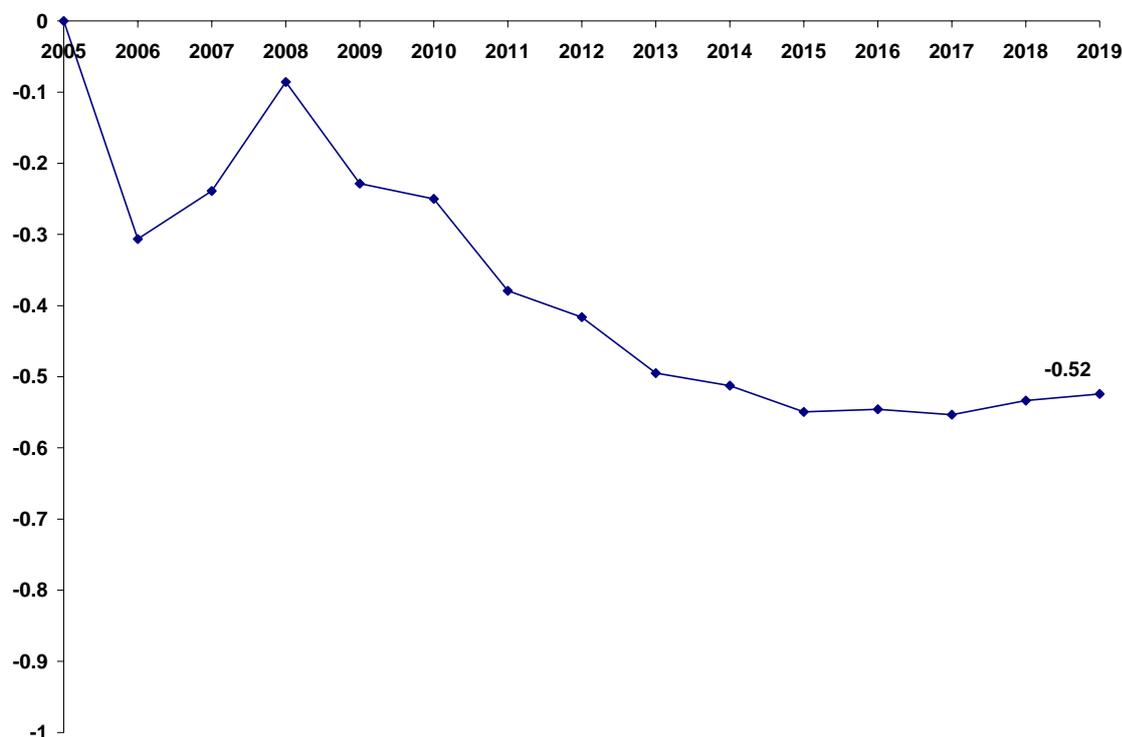
Why does USAGE-M imply that a policy of restricting the supply of foreign-illegal workers leads to a long-run reduction in the economic welfare of legal residents? More particularly, why is the reduction 0.52 per cent for a supply-restricting policy that cuts long-run illegal employment in the U.S. by 28.6 per cent? As summarized in Table 4.3, there are six factors in the model that explain this result.

Factor 1: direct illegal labor effect

The first factor is the direct illegal labor effect, encompassing the change in GDP that is directly attributable to the reduction in employment of illegal migrants compared with the change in the after-tax cost of employing them.

¹⁶ In popular discussions it is often asserted that cuts in employment of illegal migrants would reduce unemployment rates of low-skilled domestic workers. Our modeling does not support this view. In fact, with cuts in illegal immigration, low-skilled domestic workers might find themselves under increased pressure from higher-skilled workers who can no longer find vacancies in higher-skilled occupations.

Chart 4.11. Consumption (private and public) by legal residents in the SR simulation (percentage deviation from basecase)



We illustrate the direct effect in Figure 4.1 which we call a Borjas diagram.¹⁷ DD is the demand curve for illegal migrants in the U.S., drawn as a function of the unit cost of employing them. In the SR simulation, this is simply the pre-income-tax wage rate for foreign-illegal employees.¹⁸ SS is the supply curve for illegal migrants in the basecase run and S'S' is the supply curve in the policy run. Both SS and S'S' relate supply to pre-income-tax wage rates and are drawn on the assumption that the income-tax rate applying to illegal migrants is held constant (at 11.95 per cent, L11 in Table 4.3).

The numbers in Figure 4.1 refer to simulation results for 2019. In the basecase for 2019, the average pre-tax wage rate for foreign-illegal workers is \$1, rising to \$1.09231 in the policy run.¹⁹ The 2019 basecase U.S. wagebill is \$17,941,636m. As mentioned in subsection 4.1, the share of illegal workers in the total wagebill is 3.64 per cent. Thus, with the wage rate at \$1, basecase employment of illegal migrants in 2019 is 653076m units (=0.0364*17,941,636m).²⁰ In the policy run, the quantity of illegal migrant employment is 28.6 per cent lower, 466468m units.

¹⁷ Borjas (1995 and 1999) uses similar diagrams to explain the effects on the incomes of the native population of changes in the number of migrants.

¹⁸ In section 5 we introduce a tax on employers of illegal migrants and this drives a wedge between the unit cost to employers and the pre-income-tax wage rate.

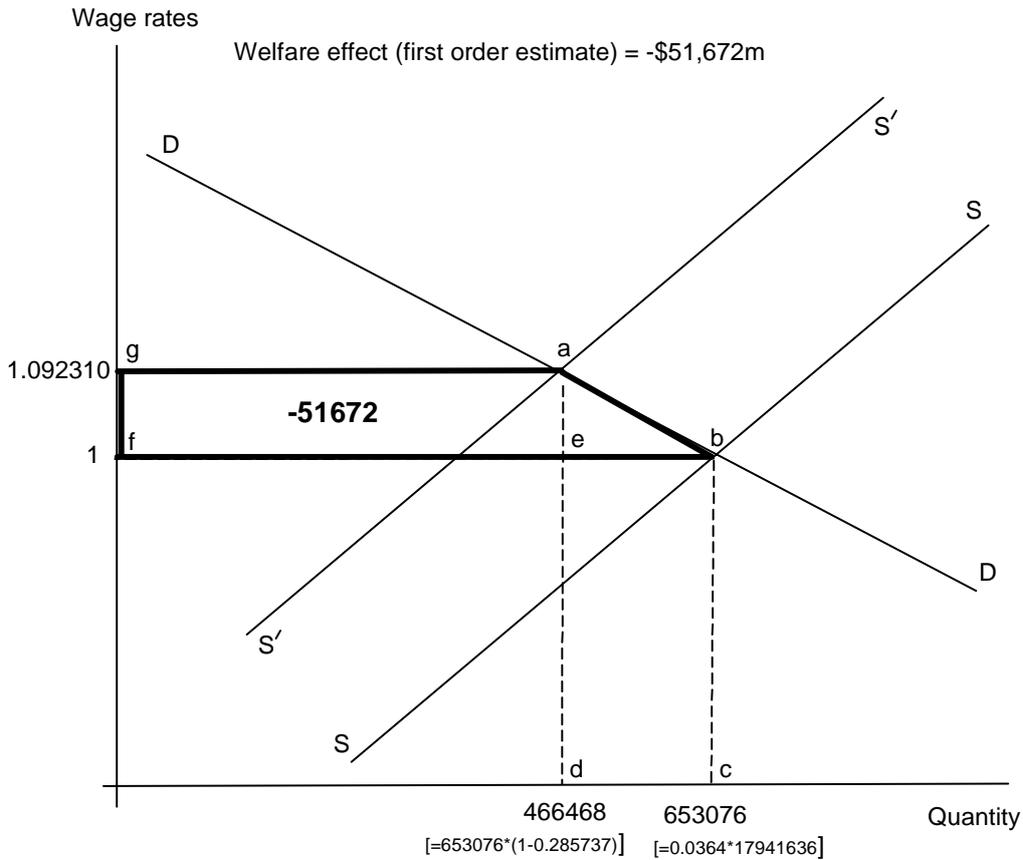
¹⁹ As mentioned in subsection 4.5, the foreign-illegal wage deflated by consumer prices rises by 9.5 per cent. The wage referred to in Figure 4.1 is deflated by the price deflator for GDP.

²⁰ With basecase employment of illegal migrants in 2019 being 12.4 million people, the average nominal wage per illegal worker is \$52,624 (= 653076/12.4). This incorporates growth between 2005 and 2019 of about 50 per cent in prices and 46 per cent in average real wages across the economy.

Table 4.3. SR simulation: why does consumption of legal residents decline by 0.52 per cent in the long run?

| Basecase data for 2019 | | \$million or fraction | | % deviation in 2019 | |
|--|---|-----------------------|-----------|--|----------|
| L1 | GDP | 25,600,320 | P1 | Foreign illegal employment | -28.5737 |
| L2 | Private consumption | 17,881,766 | P2 | Foreign illegal wage rate, cost to employers | 9.2310 |
| L3 | Public consumption | 4,222,785 | P3 | Foreign illegal wage rate, pre-income-tax | 9.2310 |
| L4 | Investment | 5,437,971 | P4 | Occupation-mix effect on average hourly wage rate of legal workers | -0.4647 |
| L5 | Aggregate exports | 3,901,019 | P5 | Capital stock | -1.7134 |
| L6 | Aggregate imports | 5,843,221 | P6 | Price deflator for GDP | 0 |
| L7 | Returns to capital | 6,536,265 | P7 | Price deflator for private consumption | -0.2808 |
| L8 | Aggregate wagebill | 17,941,636 | P8 | Price deflator for public consumption | -0.0173 |
| L9 | Indirect taxes | 1,122,420 | P9 | Price deflator for investment | 0.1482 |
| L10 | Indirect tax rate on U.S. output (T1) | 0.0438 | P10 | Price deflator for exports | -0.3501 |
| L11 | Tax rate on foreign illegal income (T2) | 0.1195 | P11 | Price deflator for imports | -1.1456 |
| L12 | Tax rate on capital income | 0.1476 | P12 | Price deflator for consumption (priv. & pub.) | -0.2305 |
| L13 | Share of U.S. capital domestically owned | 0.8013 | P13 | Price deflator for GNE | -0.1557 |
| L14 | Share of foreign illegal workers in wagebill | 0.0364 | P14 | Terms of trade | 0.7955 |
| L15 | Share of illegals in public consumption | 0.0370 | P15 | U.S. capital domestically owned | -0.9428 |
| L16 | GNP for legal residents | 26,210,266 | P16 | U.S. capital foreign owned | -4.8202 |
| | | | P17 | Employment of legal workers | -0.1553 |
| Six factors explaining the long-run reduction in consumption by legal residents | | | \$million | Per cent of GNP for legal residents | |
| F1 | Direct illegal labor effect: $-(P2/100)*L14*L8*(2+P1/100)/2 + L10*L14*L8*(P1/100)*(2+P2/100)/2 + L11*\{ L8*L14*(P1/100) + (P2/100)*L14*L8*(1+P1/100) \}$ | | -77,305 | -0.29 | |
| F2 | Occupation mix effect: $(P4/100)*L8*(1-L14)$ | | -80,343 | -0.31 | |
| F3 | Capital effect: $L7*L13*(P15/100) + L7*(1-L13)*(P16/100)*L12 + L7*L10*(P5/100)$ | | -63,524 | -0.24 | |
| F4 | Legal employment effect: $(P17/100)*L8*(1-L14)*(1+L10)$ | | -28,027 | -0.11 | |
| F5 | Public expenditure effect: $-L15*L3*(P1/100)$ | | 44,617 | 0.17 | |
| F6 | Terms-of-trade and other macro price effects: $L16*(P6 - P12)/100$ | | 60,405 | 0.23 | |
| Back-of-the-envelope totals | | | -144178 | -0.55 | |
| USAGE-M result | | | | -0.52 | |

Figure 4.1. Borjas diagram for SR simulation: demand for and supply of illegal migrants in 2019



A back-of-the-envelope specification of the demand curve DD is

$$\text{Wage}(\text{illegal}) = \frac{P_g}{(1 + T_1)} * \text{MPL}(\text{illegal}) \quad (4.2)$$

where

Wage (illegal) is the wage rate (as a cost to employers) for illegal migrants;

P_g is the price deflator for GDP, that is the price of U.S. products;

MPL(illegal) is the marginal product of illegal workers; and

T_1 is the average rate of indirect tax applying to U.S. output.

Equation (4.2) puts the wage rate of illegal migrants equal to the value of their marginal product to employers, allowing for indirect taxes.

Under (4.2), the direct effect on U.S. GDP of reducing foreign-illegal employment by one unit is $P_g * \text{MPL}(\text{illegal})$. Thus, a 28.6 per cent cut in employment of illegal migrants directly reduces U.S. GDP by the area abcd in Figure 4.1 multiplied by $(1 + T_1)$.²¹ Pre-tax payments to illegal workers are reduced by the area bcde, reflecting the reduction in their

²¹ This is not quite true because the reduction in illegal employment causes a reduction in capital stock so that points a and b in Figure 4.1 are not really on the same demand curve. However, the policy-induced reduction in the capital stock (1.7 per cent, Chart 4.4), and therefore the shift in the demand curve for illegal workers, is relatively small and can be ignored in a back-of-the-envelope calculation.

employment, but are increased by the area aefg, reflecting the increase in their wage rates. In after-tax terms, the change in payments to foreign-illegal workers is

$$\Delta \text{ATWagebill}(\text{illegal}) = (1 - T_2) * [\text{area}(\text{aefg}) - \text{area}(\text{bcde})] \quad (4.3)$$

where

T_2 is the rate of income tax applying to the wages of foreign-illegal workers.

In total, the direct effect on the income of legal residents of the reduction in illegal employment is:

$$\begin{aligned} \text{Direct effect} &= -(1 + T_1) * \text{area}(\text{abcd}) - (1 - T_2) * [\text{area}(\text{aefg}) - \text{area}(\text{bcde})] \\ &= -\text{area}(\text{abfg}) - T_1 * \text{area}(\text{abcd}) - T_2 * [\text{area}(\text{bcde}) - \text{area}(\text{aefg})]. \end{aligned} \quad (4.4)$$

In the absence of taxes, the direct effect would be a loss of income for legal residents of area abfg, made up of a loss of producer surplus of abe plus a transfer from U.S. employers to illegal migrants of aefg. As indicated in Figure 4.1, this is worth \$51,672m [=0.09231*(653076+466468)/2]. However, the USAGE-M database indicates that the average indirect tax rate (T_1) is 4.38 per cent and, as explained in Appendix 1 (to be made available by the authors), we assume that the rate of tax (T_2) on the wages of illegal migrants is 11.95 per cent. Taking these taxes into account increases the direct loss to \$77,305m. This is 0.29 per cent of the basecase value of the income of legal residents in 2019 (that is, GNP for legal residents of \$26,210,266m, Table 4.3).

Factor 2: occupation-mix effect

As we saw in subsection 4.4, restricting the supply of illegal migrants changes the occupational mix of employment of legal residents. This is predominantly towards low-paid occupations. Thus, a cost of restricting illegal immigration is that it opens up employment opportunities for legal workers in low-paid (low-marginal product) occupations relative to high-paid (high-marginal product) occupations.

Using basecase occupational wage rates for 2019, we calculate that the shift in the occupational mix of legal employment in our SR simulation reduces the average hourly wage rate of legal workers by 0.4647 per cent. In making this calculation we use the formula:

$$\begin{aligned} \text{Occupation-mix effect on wage rate of legal residents} &= \\ 100 * \left\{ \frac{\sum_j \sum_o W_{b2019}(o, j, \text{leg}) * [H_{p019}^*(o, j, \text{leg}) - H_{b2019}(o, j, \text{leg})]}{\sum_j \sum_o W_{b2019}(o, j, \text{leg}) * H_{b2019}(o, j, \text{leg})} \right\}, \end{aligned} \quad (4.5)$$

where

$W_{b2019}(o, j, \text{leg})$ is the wage rate of legal workers of occupation o and industry j in the basecase for 2019;

$H_{b2019}(o, j, \text{leg})$ is total hours of legal workers of occupation o and industry j in the basecase for 2019; and

$H_{p2019}^*(o, j, \text{leg})$ is total normalized hours of legal workers of occupation o and industry j in the policy run for 2019. We normalize by adjusting hours in each (o,j) cell by the same proportion so that the sum of the normalized hours is the same as in the basecase. In this way, we abstract from effects of changes in total legal employment.

The total cost to legal residents of the occupation-mix effect in 2019 is \$80,343m, calculated as the wage effect times the basecase wagebill of legal residents (that is, $0.04647 \cdot (1-0.364) \cdot 17941636$, Table 4.3). It could be argued that at least some of this effect should be offset by a reduction in training costs. However, we have not attempted to make such an offset.

A question that we have been asked about the occupation-mix effect is why would legal workers give up jobs in high-paid occupations and shift to low-paid occupations. We are not implying that significant numbers of existing legal workers will change their occupations. For each occupation, restricting the supply of illegal workers will have two effects on employment opportunities for legal workers. First, the reduction in illegal employment will generate opportunities for legal workers to replace illegal workers. Second, the economy will be smaller, generating a negative effect on employment opportunities for legal workers. The positive replacement effect will dominate in the low-paid occupations that currently employ large numbers of illegal migrants. The negative effect of having a smaller economy will dominate in high-paid occupations that currently employ very few illegal migrants. Thus, there will be an increase in vacancies in low-paid occupations relative to high-paid occupations, allowing low-paid occupations to absorb an increased proportion of both new entrants to the workforce and unemployed workers.

Factor 3: capital effect

As discussed in subsection 4.2, the SR simulation shows a -1.7 per cent deviation in the U.S. capital stock (Chart 4.4). With the basecase capital share in GDP in 2019 being about 26 per cent, the reduction in capital causes a direct reduction in GDP in 2019 of about 0.44 per cent ($= 1.7 \cdot 0.26$). To get from here to the capital effect on the income of legal residents, we need to take account two factors: the U.S. share in the ownership of capital in the U.S. and capital taxation issues.

In the basecase for 2019, the U.S. share in the ownership of U.S. capital is 80.13 per cent (Table 4.3). The deviation in capital in 2019 of -1.7 per cent is composed of a 0.9428 per cent reduction in U.S.-owned capital and a 4.8202 per cent reduction in foreign-owned capital (Table 4.3). This means that about 57 per cent of the reduction in U.S. capital is a reduction in foreign-owned capital in the U.S. [$0.57 = 4.8202 \cdot (1-0.8013) / 1.7134$]. As implied by USAGE-M, a reduction in illegal employment has a much sharper percentage effect on capital than it does on the income, and therefore the savings, of legal residents. This explains why foreign investment is so heavily represented in the 1.7 per cent reduction in U.S. capital.

In the absence of tax effects, a reduction in U.S.-owned capital of 0.9428 per cent would cause a reduction in the 2019 income of legal residents of \$49,378m. This is 0.009428 times the U.S. component of U.S. capital income ($= 0.8013 \cdot 6536265$). However, as in the case of the direct-illegal-labor effect, taxes are significant.

The 4.8202 per cent reduction in foreign-owned capital causes a loss of capital income-tax revenue to the U.S. of \$9,238m. This is calculated as 4.8202 per cent of foreign-owned capital income [$= (1-0.8013) \cdot 6536265$] times the capital tax rate which we assume is 14.756 per cent.

There is also an indirect tax effect. As in the case of labor, the value of the marginal product of capital is $1+T_1$ times the return to a unit of capital. Consequently, a reduction in capital stock imposes a loss of GDP beyond the direct effect on the returns to capital. In the present case, this additional loss in GDP, which is borne by legal residents, is \$4,911m, calculated as the indirect tax rate (0.04385) times 1.7 per cent of the total returns to capital.

In aggregate, the capital effect imposes a loss on legal residents of \$63,524 (= 49378+ 9238 + 4911).

Factor 4: legal-employment effect

Subsection 4.5 explains that the 2019 deviation in legal employment is -0.1553 per cent. This imposes a direct loss on legal residents of \$26,849m, calculated as 0.1553 per cent of the basecase labor income of legal residents [= (1-0.0364)*17941636]. There is a further loss via indirect taxes: the value of the marginal product of legal workers is $1+T_1$ times their wage rate. Taking this into account gives an additional loss of \$1,177m (=0.04385*26849). Consequently, the total loss from the reduction in legal employment is \$28,027m.

Factor 5: public expenditure effect

In 2005, illegal migrants and their dependents in the U.S. accounted for about 4.86 per cent of the U.S. population. As explained in the Appendix 1 (to be made available by the authors), we estimate that their presence in the U.S. accounted for 2.45 per cent of public consumption. This covers education, health and law enforcement expenditures that would not have been undertaken if the illegal migrants and their families were not in the U.S. Thus, we assume that public expenditure per illegal migrant is 0.49 times public expenditure per legal resident [= (0.0245/0.0486)/((1-0.0245)/(1-0.0486))]. In our basecase for 2019, the share of illegal migrants and their dependents in the U.S. population grows to 7.24 per cent. We assume that the 0.49 ratio of public expenditure on illegal residents to that on legal residents is maintained. Thus in our basecase for 2019, the share of illegals in public expenditure is 3.70 per cent [0.49*0.0724/(0.49*0.0724+1-0.0724)].

With a 28.6 per cent reduction in the number of illegal migrants, the public sector reduces its expenditure in 2019 by \$44,617m, calculated as 28.6 per cent of 3.7 per cent of public consumption. As shown in Table 4.3, this is a benefit to legal residents.

Factor 6: terms-of-trade and other macro-price effects

Table 4.3 shows a deviation in the price deflator for private and public consumption of -0.2305. The price deflator for GDP is the numeraire (with an assumed zero deviation). Thus, in the SR simulation, USAGE-M implies that a 28.6 per cent reduction in illegal employment has price effects that increase the consuming power of the income of legal residents by 0.2305 per cent. From the point of view of consumption by legal residents, the price effects are equivalent to an increase in income of \$60,405m (calculated as 0.2305 per cent of the GNP of legal residents, Table 4.3).

The main reason for the decline in the price of consumption relative to the price of GDP is the improvement in the terms of trade discussed in subsection 4.2 (0.7955 in Table 4.3). A terms-of-trade improvement reduces the price deflator for gross national expenditure (GNE) relative to the price deflator for GDP. The dominant component of GNE is consumption. Thus, a reduction in the price deflator for GNE relative to that for GDP tends to reduce the price deflator for consumption relative to that for GDP. The reason that a terms-of-trade improvement reduces the GNE deflator relative to the GDP deflator is that the GNE includes imports but not exports, whereas GDP includes exports but not imports. In the SR simulation, the reduction in the price of consumption relative to the price of GDP is accentuated by movements in the component price deflators of GNE. Table 4.3 shows a decline in the price of consumption relative to the price of GNE. This is because there is a decline in the price of consumption relative to the price of the other component of GNE, namely investment (-0.2305 compared with 0.1482). In the SR policy run, the price of investment is elevated relative to the price of consumption because of the heavy representation of illegal migrants in the construction industry.

Overview

The calculations in Table 4.3 imply a long-run reduction in consumption by legal residents of 0.55 per cent, close to the USAGE-M result of 0.52 per cent. This gives us confidence that our back-of-the-envelope explanations capture the mechanisms underlying the determination in USAGE-M of the result for consumption by legal residents.

Table 4.3 shows that restricting the supply of foreign illegal labor has a variety of negative and positive effects on consumption by legal residents. Some of these are direct effects, closely tied to the market for foreign-illegal labor and related provision of public services. In Table 4.3 these direct effects are F1, F2 and F5. While general equilibrium modeling is the ideal framework for analyzing these effects, they could also be analyzed in a partial equilibrium framework. The other effects in Table 4.3 (F3, F4 and F6) are indirect and are a consequence of the working of the macro economy. Their analysis can only be undertaken in a general equilibrium framework.

The largest negative contribution to consumption by legal residents identified in Table 4.3 is the occupation-mix effect. Reduction in foreign-illegal employment would shift the occupational composition of employment of legal residents towards low-skilled, low-paid jobs. This would reduce the income of legal residents.

The next largest negative contribution is the direct-illegal-labor effect encompassing: a loss of producer surplus; a transfer of income from U.S. employers to illegal migrants via an increase in their wage rates; and direct and indirect tax effects. We explained the direct-illegal-labor effect largely in terms of a Borjas diagram, showing demand and supply curves for illegal labor.

A third significant contribution is the capital effect. A reduction in foreign-illegal employment would cause the U.S. capital holdings of both residents and foreigners to be smaller than they otherwise would have been. The reduction in resident holdings would directly reduce the income and consumption of legal residents. The reduction in foreign holdings would indirectly reduce the income and consumption of legal residents via a loss of taxation revenue on foreign income earned in the U.S.

Table 4.3 shows a minor negative effect on consumption of legal residents from a long-run reduction in their total employment.

The final two effects, F5 and F6, are positive. F5 quantifies the benefits to legal residents of the reduction in public expenditure directly related to illegal migrants. F6 quantifies the benefits from an improvement in the U.S. terms of trade. With a smaller economy, the U.S. would reduce its exports allowing the foreign-currency prices of U.S. goods to be higher than they otherwise would have been.

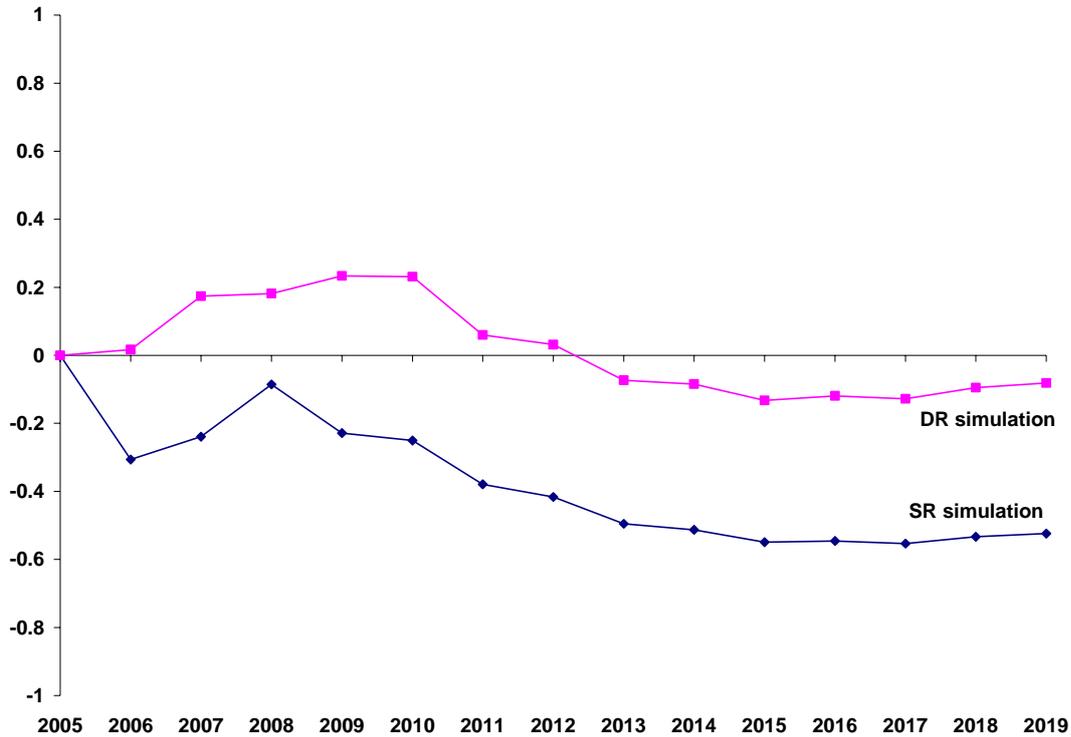
5. Restricting the demand for foreign-illegal labor in the U.S. by taxes on employers

In this section we use USAGE-M to compute the effects on the U.S. economy of the imposition of a surtax on employers of illegal migrants.²² The aim of the policy is to reduce employment of illegal migrants by reducing demand for their services. We refer to the simulation as simulation DR (Demand Restriction).

The DR basecase run is the same as that in the SR simulation. In the DR policy run the shock (the surtax) is phased in over the four years from 2006 to 2009. The size of the shock is calibrated so that the effect in 2019 on employment of illegal migrants is approximately the same as that in the SR simulation, a reduction of 28.6 per cent.

²² Literally, we impose the shocks as increases in the tax rate applying to illegal migrant wages (an increase in $T_t(b,s)$ for $b = \text{foreign}$ and $s = \text{illegal}$, subsection 3.5).

Chart 5.1. Consumption (private & public) by legal residents in the SR and DR simulations (percentage deviation from basecase)



The deviation results in the DR simulation for nearly all variables are very similar to those in the SR simulation. However, for consumption of legal residents the results are quite different, as shown in Chart 5.1. The damage to legal residents is considerably reduced when employment of illegal migrants is curtailed by a demand-reducing tax rather than supply-side restrictions.

Table 5.1 analyzes the long-run DR result for consumption by legal residents in the same way that Table 4.3 analyzed the long-run SR result. To facilitate comparison of the two tables, we have reproduced key numbers from them in Table 5.2.

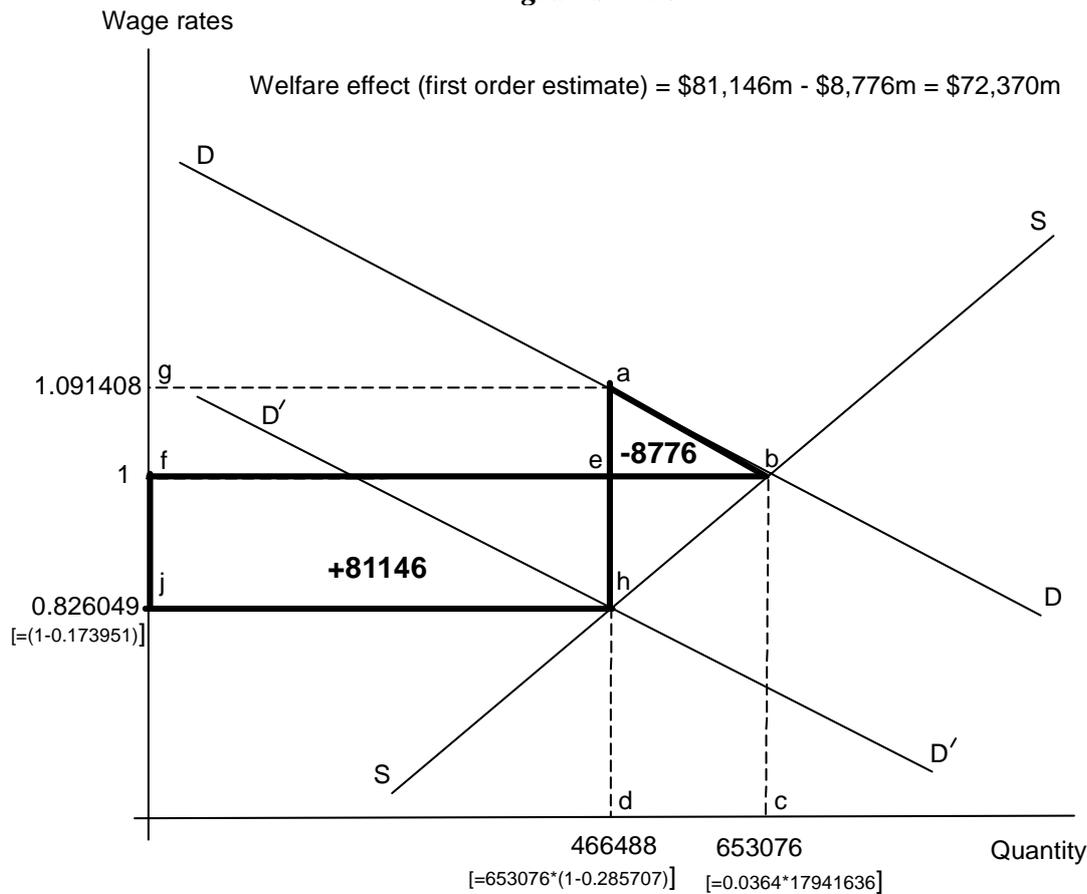
From Table 5.2 we see that the bulk of the difference between the long-run DR and SR results for consumption by legal residents is due to the direct illegal labor effect. This switches from -0.29 per cent in the SR simulation to +0.12 per cent in the DR simulation. The switch reflects what happens to the pre-income-tax wage rate of illegal migrants. In the SR simulation, their average pre-income-tax wage rate rose by 9.2 per cent (result P3 in Table 4.3). In the DR simulation, their average pre-income-tax wage rate falls by 17.4 per cent (result P3 in Table 5.1). In the SR simulation, the reduction in the employment of illegal migrants caused a transfer of income from U.S. employers to illegal migrants via higher wages. Now, in the DR simulation, the reduction in the employment of illegal migrants causes a transfer from illegal migrants (and employers) to the U.S. treasury via the surtax.

The Borjas diagram for the DR simulation is drawn as Figure 5.1. As in Figure 4.1, DD and SS are the basecase demand and supply curves for illegal migrants in the U.S. D'D' is the demand curve in the policy run with the surtax in place. Again, as in Figure 4.1, the numbers in the Figure 5.1 refer to simulation results for 2019.

Table 5.1. DR simulation: why does consumption of legal residents decline by 0.08 per cent in the long run?

| Basecase data for 2019 | | \$million or fraction | | | % deviation in 2019 |
|--|---|-----------------------|-----|--|-------------------------------------|
| L1 | GDP | 25,600,320 | P1 | Foreign illegal employment | -28.5707 |
| L2 | Private consumption | 17,881,766 | P2 | Foreign illegal wage rate, cost to employers | 9.1408 |
| L3 | Public consumption | 4,222,785 | P3 | Foreign illegal wage rate, pre-income-tax | -17.3951 |
| L4 | Investment | 5,437,971 | P4 | Occupation-mix effect on average hourly wage rate of legal workers | -0.4714 |
| L5 | Aggregate exports | 3,901,019 | P5 | Capital stock | -1.6948 |
| L6 | Aggregate imports | 5,843,221 | P6 | Price deflator for GDP | 0 |
| L7 | Returns to capital | 6,536,265 | P7 | Price deflator for private consumption | -0.3034 |
| L8 | Aggregate wagebill | 17,941,636 | P8 | Price deflator for public consumption | -0.0232 |
| L9 | Indirect taxes | 1,122,420 | P9 | Price deflator for investment | 0.0404 |
| L10 | Indirect tax rate on U.S. output (T1) | 0.0438 | P10 | Price deflator for exports | -0.4923 |
| L11 | Tax rate on foreign illegal income (T2) | 0.1195 | P11 | Price deflator for imports | -1.3750 |
| L12 | Tax rate on capital income | 0.1476 | P12 | Price deflator for consumption (priv. & pub.) | -0.2499 |
| L13 | Share of U.S. capital domestically owned | 0.8013 | P13 | Price deflator for GNE | -0.1927 |
| L14 | Share of foreign illegal workers in wagebill | 0.0364 | P14 | Terms of trade | 0.8827 |
| L15 | Share of illegals in public consumption | 0.0370 | P15 | U.S. capital domestically owned | -0.5747 |
| L16 | GNP for legal residents | 26,210,266 | P16 | U.S. capital foreign owned | -6.2107 |
| | | | P17 | Employment of legal workers | -0.1423 |
| Six factors explaining the long-run reduction in consumption by legal residents | | | | \$million | Per cent of GNP for legal residents |
| F1 | Direct illegal labor effect: Direct effect (SR) + (1- L11)*(P2/100-P3/100)*L8*L14*(1+P1/100) | | | 32,036 | 0.12 |
| F2 | Occupation mix effect: (P4/100)*L8*(1-L14) | | | -81,501 | -0.31 |
| F3 | Capital effect: L7*L13*(P15/100) + L7*(1-L13)*(P16/100)*L12 + L7*L10*(P5/100) | | | -46,861 | -0.18 |
| F4 | Legal employment effect: (P17/100)*L8*(1-L14)*(1+L10) | | | -25,681 | -0.10 |
| F5 | Public expenditure effect: -L15*L3*(P1/100) | | | 44,614 | 0.17 |
| F6 | Terms-of trade and other macro price effects: L16*(P6 - P12)/100 | | | 65,492 | 0.25 |
| Back-of-the-envelope totals | | | | -11902 | -0.05 |
| USAGE-M result | | | | | -0.08 |

Figure 5.1. Borjas diagram for DR simulation: demand for and supply of illegal migrants in 2019



In terms of Figure 5.1 the direct illegal labor effect on the income of legal residents is given by

$$\text{Direct effect(DR)} = \text{Direct effect(SR)} + (1 - T_2) * \text{area(ahjg)} . \quad (5.1)$$

In (5.1) we have added $(1-T_2) * \text{area(ahjg)}$ to the right-hand side of formula (4.4) used for the SR simulation. If we applied formula (4.4) in the DR case, then we would be assuming that the pre-income-tax wage rate rises to 1.0914.²³ The extra term recognizes that with the surcharge in place, area(ahjg) is not part of the income of illegal migrants. Instead, it is revenue for the U.S. Treasury. The multiplier $(1-T_2)$ in the extra term recognizes that income tax on foreign-illegal wages is collected on a pre-income-tax wage rate of 0.8260 rather than 1.0914.

In the special case in which T_1 and T_2 are zero, the direct effect for the DR simulation is represented neatly in Figure 5.1 as area(ehjf) less area(abe).

While the switch in the direct illegal labor effect is the main source of difference between the SR and DR results for consumption of legal residents, Table 5.2 reveals one other significant source, the capital effect (F3). This is more favorable in the DR simulation than in the SR simulation because of the more favorable result for U.S. capital domestically owned (P15 in Tables 5.1 and 4.3). In the SR simulation the deviation in this variable is -0.9428 whereas in the DR simulation it is -0.5747. In the DR policy run the income, and

²³ In (5.1) we ignore the slight discrepancy between the SR and DR simulations in the movements of the foreign-illegal wage rate as a cost to employers (9.2310 per cent in the SR simulation and 9.1408 per cent in the DR simulation).

Table 5.2. Long-run percentage effects on consumption of legal residents

| | | SR simulation | DR simulation |
|----|---|---------------|---------------|
| F1 | Direct illegal labor effect | -0.29 | 0.12 |
| F2 | Occupation mix effect | -0.31 | -0.31 |
| F3 | Capital effect | -0.24 | -0.18 |
| F4 | Legal employment effect | -0.11 | -0.10 |
| F5 | Public expenditure effect | 0.17 | 0.17 |
| F6 | Terms-of-trade and other macro price effects | 0.23 | 0.25 |
| | Back-of-the-envelope totals | -0.55 | -0.05 |
| | USAGE-M result | -0.52 | -0.08 |

therefore savings, of legal residents is higher throughout the simulation period than in the SR policy run. This reflects the more favorable direct-illegal-labor effect in the DR simulation compared with the SR simulation.

6. Sensitivity analysis

In this section we look at how our results from sections 4 and 5 are affected by varying critical assumptions and parameter values. We start in subsection 6.1 by varying a basic assumption of the demand-side simulation described in section 5. Rather than assuming that employers of illegal migrants pay a tax to the U.S. Treasury, we simulate the effects of a demand-reducing policy that imposes resource-using costs on employers of illegal migrants. In subsection 6.2 we vary our assumption concerning the level of public services provided to illegal migrants. Subsection 6.3 shows the effects of varying the scale of the programs considered in sections 4 and 5. We simulate the effects of employment reductions that are half and twice as big as those in the SR and DR simulations. Finally, in subsections 6.4 and 6.5, we vary parameters that determine the demand for and supply of illegal migrants.

6.1. Restricting the demand for foreign-illegal labor in the U.S. by punitive measures on employers

In section 5 we assumed that the whole of the gap between the wage of foreign illegal workers as a cost to employers and the wage received by foreign illegal workers is transferred to the U.S. Treasury as a surtax. In this subsection we make an alternative assumption. We assume that the gap is dissipated as resource-using costs to employers. This situation could arise when law-enforcement authorities follow a policy of raids, prosecutions and business closures, inducing businesses to hire lawyers, accountants and other professionals to mitigate damages.

We continue to adopt the basecase from the DR and SR simulations. Now, in the policy run we assume that businesses that hire illegal migrants also feel obliged to hire complementary domestic professional workers. This increases the cost of using foreign-illegal labor. In the policy run, the quantity of complementary domestic professional workers per unit of illegal labor is set so that the long-run effect on foreign-illegal employment is again a reduction of about 28 per cent. We refer to the new simulation as simulation RA (raid).

As in section 5, we will concentrate on the results for consumption by legal residents. The RA simulation results for this variable are close to those in the SR

Table 6.1. RA simulation: why does consumption of legal residents decline by 0.47 per cent in the long run?

| Basecase data for 2019 | | \$million or fraction | | | % deviation in 2019 |
|--|--|-----------------------|-----------|--|---------------------|
| L1 | GDP | 25,600,320 | P1 | Foreign illegal employment | -28.4065 |
| L2 | Private consumption | 17,881,766 | P2 | Foreign illegal wage rate, cost to employers | 9.1369 |
| L3 | Public consumption | 4,222,785 | P3 | Foreign illegal wage rate, pre-income-tax | -17.3312 |
| L4 | Investment | 5,437,971 | P4 | Occupation-mix effect on average hourly wage rate of legal workers | -0.3383 |
| L5 | Aggregate exports | 3,901,019 | P5 | Capital stock | -2.0908 |
| L6 | Aggregate imports | 5,843,221 | P6 | Price deflator for GDP | 0 |
| L7 | Returns to capital | 6,536,265 | P7 | Price deflator for private consumption | -0.3757 |
| L8 | Aggregate wagebill | 17,941,636 | P8 | Price deflator for public consumption | 0.0540 |
| L9 | Indirect taxes | 1,122,420 | P9 | Price deflator for investment | 0.0103 |
| L10 | Indirect tax rate on U.S. output (T1) | 0.0438 | P10 | Price deflator for exports | -0.5181 |
| L11 | Tax rate on foreign illegal income (T2) | 0.1195 | P11 | Price deflator for imports | -1.6365 |
| L12 | Tax rate on capital income | 0.1476 | P12 | Price deflator for consumption (priv. & pub.) | -0.2936 |
| L13 | Share of U.S. capital domestically owned | 0.8013 | P13 | Price deflator for GNE | -0.2336 |
| L14 | Share of foreign illegal workers in wagebill | 0.0364 | P14 | Terms of trade | 1.1184 |
| L15 | Share of illegals in public consumption | 0.0370 | P15 | U.S. capital domestically owned | -0.9347 |
| L16 | GNP for legal residents | 26,210,266 | P16 | U.S. capital foreign owned | -6.7514 |
| | | | P17 | Employment of legal workers | -0.1231 |
| Six factors explaining the long-run reduction in consumption by legal residents | | | \$million | Per cent of GNP for legal residents | |
| F1 | Direct illegal labor effect: : Direct effect (DR) - (P2/100-P3/100)*L8*L14*(1+P1/100) | | -91,462 | | -0.35 |
| F2 | Occupation mix effect: (P4/100)*L8*(1-L14) | | -58,495 | | -0.22 |
| F3 | Capital effect: L7*L13*(P15/100) + L7*(1-L13)*(P16/100)*L12 + L7*L10*(P5/100) | | -67,885 | | -0.26 |
| F4 | Legal employment effect: (P17/100)*L8*(1-L14)*(1+L10) | | -22,218 | | -0.08 |
| F5 | Public expenditure effect: -L15*L3*(P1/100) | | 44,359 | | 0.17 |
| F6 | Terms-of-trade and other macro price effects: L16*(P6 - P12)/100 | | 76,952 | | 0.29 |
| | | | -118,749 | | -0.45 |
| | | | | USAGE-M result | -0.47 |

Table 6.2. Long-run percentage effects on consumption of legal residents

| | | SR simulation | DR simulation | RA simulation |
|------------------------------------|--|------------------|------------------|------------------|
| F1 | Direct illegal labor effect | -0.29 | 0.12 | -0.35 |
| F2 | Occupation mix effect | -0.31 | -0.31 | -0.22 |
| F3 | Capital effect | -0.24 | -0.18 | -0.26 |
| F4 | Legal employment effect | -0.11 | -0.10 | -0.08 |
| F5 | Public expenditure effect | 0.17 | 0.17 | 0.17 |
| F6 | Terms-of-trade and other macro price effects | 0.23 | 0.25 | 0.29 |
| Back-of-the-envelope totals | | -0.55 | -0.05 | -0.45 |
| USAGE-M result | | -0.52 | -0.08 | -0.47 |

Chart 6.1. Consumption (private & public) by legal residents in the SR and DR simulations (percentage deviation from basecase)



simulation, see Chart 6.1. The 2019 RA result for consumption by legal residents is analyzed in Table 6.1, which is similar to Tables 4.3 and 5.1. Key numbers from the three tables are reproduced in Table 6.2.

While the SR and RA simulations produce quite similar long-run deviations in consumption by legal residents (-0.52 and -0.47 per cent), Table 6.2 reveals differences in the factors that make up these results. The direct illegal labor effect is noticeably more unfavorable in the RA simulation than in the SR simulation. However, this is offset by more favorable RA results for the occupation-mix and terms-of-trade effects. The other three effects, F3, F4 and F5 are quite similar for the two simulations.

To work out the direct illegal labor effect for the RA simulation we can draw a diagram similar to Figure 5.1. Then we see that the direct illegal labor effects for the RA and DR simulations are related by

$$\text{Direct effect(RA)} = \text{Direct effect(DR)} - \text{area(ahjg)} . \quad (6.1)$$

By subtracting area(ahjg) on the right hand side of (6.1) we recognize that this is the extra costs undertaken by firms to mitigate the effects of prosecutions.

Combining (5.1) and (6.1) gives

$$\text{Direct effect(RA)} = \text{Direct effect(SR)} - T_2^* \text{area(ahjg)} , \quad (6.2)$$

confirming that the direct illegal labor effect for the RA simulation must be more unfavorable than for the SR simulation. The gap, $T_2^* \text{area(ahjg)}$, is the difference between the two simulations in the income tax collections on the foreign-illegal workers who remain employed after the implementation of the policies.

The assumption in the RA policy run that employment of foreign illegals requires complementary employment of domestic professionals means that the RA simulation generates relatively favorable employment deviations for highly paid domestic workers. This is the reason for the less unfavorable RA occupation-mix effect compared with the SR occupation-mix effect.

The more favorable terms-of-trade effect in the RA simulation relative to the SR simulation is explained by a lower level of exports in the RA simulation. As mentioned in section 5, less exports allows higher foreign-currency export prices. There are two reasons that exports are lower in the RA simulation than in the SR simulation. First, as we go from SR to RA we can think of some of the consumption and remittances of foreign illegal workers as being converted into "consumption" of the services of domestic professionals. The reduction in consumption of foreign illegals reduces the demand for imports directly, thereby strengthening the exchange rate. The reduction in remittances also strengthens the exchange rate. With a higher exchange rate there is a reduction in U.S. exports. Second, the need to employ domestic professionals as a complement to foreign illegals is equivalent to a technological deterioration: more inputs are required to produce a given amount of GDP. This leads in the RA simulation to a larger negative deviation in capital stock than in the SR simulation.²⁴ With the U.S. capital stock being financed at the margin by foreigners, a lower capital stock requires lower long-run dividend and interest payments to foreigners. Again, this reduces exports in the long run via a stronger exchange rate.

6.2. Varying provision of public services to illegal migrants

As explained in section 2 and Appendix 1 (to be made available by the authors), we assumed in sections 4 and 5 that public consumption per capita devoted to illegal people is 49 per cent of that devoted to legal people, that is $\alpha = 0.49$ in equation (2.1). The assumption of 49 per cent is based on judgments concerning the extent to which each item of public expenditure varies with the number of people in families headed by illegal migrants. There is considerable room to make reasonable variations in these

²⁴ A stylized version of the marginal productivity condition for capital is $Q/P = A \cdot F(K/L)$ where Q is the rental on capital, P is the price of output, A is technology, and F is a declining function of the capital/labor ratio K/L . Q/P is a proxy for the rate of return on capital. In the long run we can assume that Q/P is determined by interest rates and risk premia independently of U.S. immigration policy. Consequently, with a lower A in the RA simulation than in the SR simulation, the RA simulation shows a lower value for K/L . L is the same in the two simulations. Consequently, K is lower in the RA simulation than in the SR simulation.

judgments. In this subsection we conduct an alternative to the SR simulation in which α is set at 0.71.

The alternative simulation produces no surprises. As can be seen in Table 6.3, the only significant difference in the long-run consumption result for legal residents is associated with factor 5, the public expenditure effect. This factor increases in the proportion 0.71/0.49, from 0.17 to 0.24.

In political discussions of the illegal migrant issue, public finance effects are dominant. Perhaps the most interesting aspect of Table 6.3 is the relative unimportance of variations in our public expenditure assumption. A 45 per cent increase in the assumed level of public expenditure on illegal migrants (an increase in α from 0.49 to 0.71) reduces the simulated negative effects on long-run consumption by legal residents in the SR simulation by only 0.09 percentage points (from -0.52 per cent to -0.43 per cent).

6.3. Varying the size of the reduction in foreign-illegal employment

Tables 6.4 and 6.5 show the effects on the long-run consumption of legal residents of scaling the shocks in the SR and DR simulations so that the long-run effects on employment of illegal migrants are halved and doubled. For the SR simulation, each of the six factors in Table 6.4 is approximately proportional to the long-run effect on illegal employment. Consequently, in USAGE-M, the long-run effect on consumption of illegal residents approximately halves as we halve the SR program and approximately doubles as we double the SR program.

In Table 6.5, the direct illegal labor effect (F1) shows a highly non-linear response to changes in long-run employment of illegal workers. As we halve the DR program, F1 declines by 25 per cent and as we double the DR program F1 changes sign. Reflecting the non-linear response of F1, USAGE-M shows a non-linear response for long-run consumption by legal residents. As we halve the DR program, the deviation in this variable moves from -0.08 to -0.00. As we double the DR program, it moves from -0.08 to -0.49.

Figure 6.1 is a starting point for understanding the difference between the behavior of F1 in the SR and DR simulations. This is a somewhat stylized picture of the relationships in the two simulations between F1 and the size of the programs. Looking back at Figure 4.1 and ignoring taxes, we can see that F1, given by $abfg$, increases monotonically as we increase the size of the SR program.²⁵ Still ignoring taxes, we see from Figure 5.1 that at small levels of the DR program the positive rectangle $ehjf$ dominates the negative triangle abe , giving a positive value for F1 (a negative value for the consumption loss in Figure 6.1). As the DR program increases, the negative triangle begins to dominate the positive rectangle. Eventually, F1 in the DR simulation must switch from positive to negative (the consumption loss in Figure 6.1 must go from negative to positive). With complete elimination of foreign illegal employment, F1 must be the same in the DR simulation as in the SR simulation.

²⁵ With a straight-line demand curve (DD in Figure 4.1), we would expect a doubling in the size of the SR program to cause less than a doubling of F1. This contradicts the result in Table 6.4 where F1 moves from -0.29 to -0.64 as we go from a reduction of 28.6 per cent in illegal employment to a reduction of 57.2 per cent. The explanation is that, unlike Figure 4.1, USAGE-M incorporates demand curves that are concave from above.

*Table 6.3. Varying the public expenditure assumption: SR percentage deviation results for consumption by legal households in 2019**

| | | $\alpha= 0.49$ | $\alpha= 0.71$ |
|----|--|----------------|----------------|
| F1 | Direct illegal labor effect | -0.29 | -0.29 |
| F2 | Occupation mix effect | -0.31 | -0.31 |
| F3 | Capital effect | -0.24 | -0.24 |
| F4 | Legal employment effect | -0.11 | -0.10 |
| F5 | Public expenditure effect | 0.17 | 0.24 |
| F6 | Terms-of-trade and other macro price effects | 0.23 | 0.23 |
| | Back-of-the-envelope totals | -0.55 | -0.48 |
| | USAGE-M result | -0.52 | -0.43 |

* In the first column of results we adopt our standard assumption that public-sector consumption undertaken on behalf of people in illegal-migrant households is 0.49 times as much per person as public-sector consumption undertaken on behalf of people in legal households, that is α equals 0.49. In the second column, we reset α at 0.71.

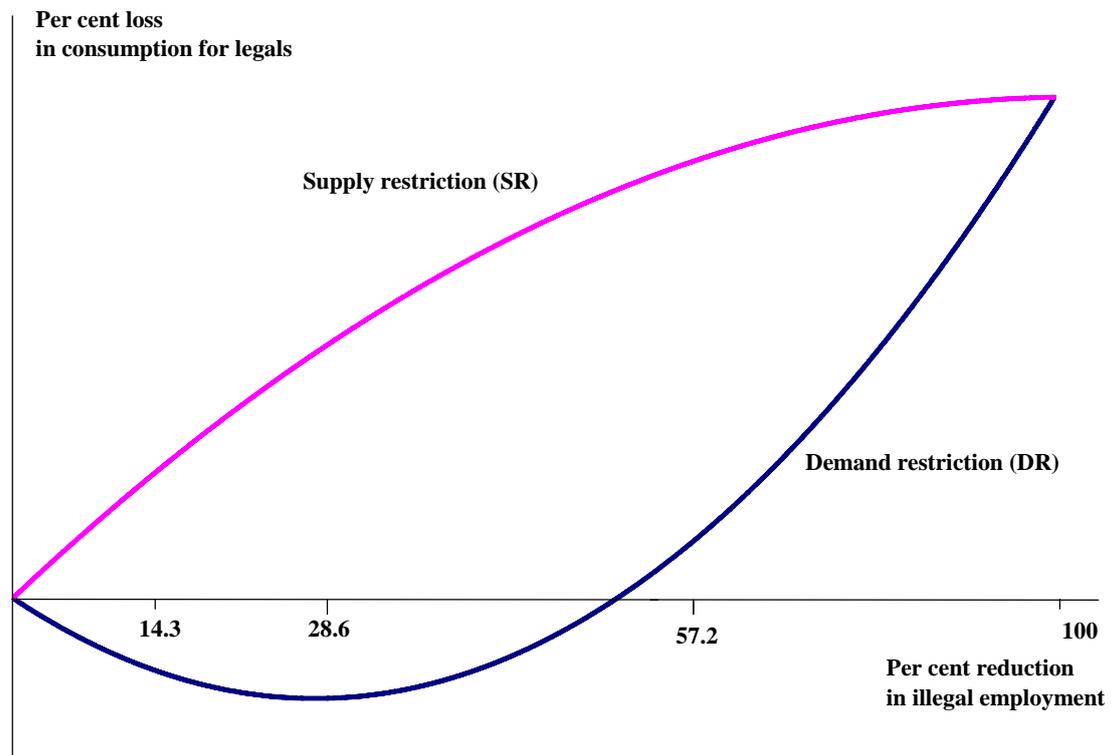
Table 6.4. Varying the size of the shocks: SR percentage deviation results for consumption by legal households in 2019

| % deviation in foreign-illegal employment in 2019 | 28.6 | 14.3 | 57.2 | |
|---|--|--------------|--------------|--------------|
| | (original) | (half) | (double) | |
| | (1) | (2) | (3) | |
| F1 | Direct illegal labor effect | -0.29 | -0.14 | -0.64 |
| F2 | Occupation mix effect | -0.31 | -0.15 | -0.66 |
| F3 | Capital effect | -0.24 | -0.12 | -0.49 |
| F4 | Legal employment effect | -0.11 | -0.05 | -0.22 |
| F5 | Public expenditure effect | 0.17 | 0.08 | 0.34 |
| F6 | Terms-of-trade and other macro price effects | 0.23 | 0.11 | 0.49 |
| | Back-of-the-envelope totals | -0.55 | -0.27 | -1.17 |
| | USAGE-M result | -0.52 | -0.26 | -1.09 |

*Table 6.5. Varying the size of the shocks: DR
percentage deviation results for consumption by legal households in 2019*

| % deviation in foreign-illegal employment in 2019 | | 28.6 (original) | 14.3 (half) | 57.2 (double) |
|---|--|--------------------|----------------|------------------|
| | | (1) | (2) | (3) |
| F1 | Direct illegal labor effect | 0.12 | 0.09 | -0.06 |
| F2 | Occupation mix effect | -0.31 | -0.15 | -0.66 |
| F3 | Capital effect | -0.18 | -0.08 | -0.41 |
| F4 | Legal employment effect | -0.10 | -0.05 | -0.22 |
| F5 | Public expenditure effect | 0.17 | 0.09 | 0.34 |
| F6 | Terms-of-trade and other macro price effects | 0.25 | 0.12 | 0.52 |
| Back-of-the-envelope totals | | -0.05 | 0.02 | -0.48 |
| USAGE-M result | | -0.08 | -0.00 | -0.49 |

Figure 6.1. Stylized behaviour of the F1 factor in SR and DR simulations



6.4. Varying key demand parameters

No hard evidence is available on the elasticity of demand for the services of illegal workers with respect to their wage rate. As explained in subsection 3.4, guided by Ottaviano and Peri (2006), we set the elasticity of substitution between domestic and foreign workers at 7.5, and without further justification we set the elasticity of substitution between legal and illegal workers at 5 (see Figure 3.2). What difference would it make to our results if we adopted different numbers for these two elasticities? To answer this question we reran the SR and DR simulation with the two substitution elasticities increased by 50 per cent, to 11.25 and 7.5. As in the original simulations, we continue to scale the policy shocks so that the long-run effect on foreign illegal employment is a reduction of 28.6 per cent.

Our main results are quite insensitive to the 50 per cent variation in substitution elasticities. As can be seen from Table 6.6, the USAGE-M long-run deviation for consumption by legal households in the SR simulation moves from -0.52 per cent to -0.50 per cent, while in the DR simulation there is no movement at two decimal places.

We had no prior reason to expect factors F2 to F6 in the explanation of the long-run consumption result for legal households for either the SR or DR simulations to be affected by a change in substitution values. As can be confirmed from Table 6.6, a 50 per cent increase in these values has almost no affect on F2 to F6.

To facilitate analysis of factor F1, we drew Figures 6.2 and 6.3. In Figure 6.2, the demand curve for foreign illegal labor with the original substitution elasticities is DD. With the higher elasticities, the demand curve becomes $D_h D'_h$. The SR shocks with the original elasticities move the supply curve from SS to $S'S'$. With the higher elasticities the shocks move the supply curve to $S''S''$: the shocks must be modified so that the effect on foreign-illegal employment remains at -28.6 per cent. Figure 6.2 suggests that with the higher elasticities the consumption loss associated with factor F1 in the SR simulation will be reduced by the striped area. As can be seen from Table 6.6, factor F1 for the SR simulation moves from a loss of 0.29 per cent to a loss of 0.25 per cent.

In Figure 6.3, we again draw the original demand curve as DD and the demand curve with the higher elasticities as $D_h D'_h$. In the original DR simulation, the demand curve moved from DD to DD' . With the higher elasticities, the demand curve moves from $D_h D'_h$ to $D_h D''_h$. On the basis of Figure 6.3, we would expect the higher elasticities to increase F1 in the DR simulation by the small striped triangle. Table 6.6 shows an increase in F1 for the DR simulation of 0.02 percentage points, from 0.12 per cent to 0.14 per cent. Consistent with Figures 6.2 and 6.3, the increase in F1 in the DR simulation is less than that in the SR simulation.

6.5. Varying the key supply parameter

In this subsection we consider the effects of moving the supply parameter η appearing in (3.8). As mentioned in subsection 3.3, η was set a 2 for the simulations in sections 4 and 5. Table 6.7 reports SR and DR simulations in which η was lowered to 1.5. A lower value for η implies steeper labor supply curves to work activities. In particular, it implies a steeper supply curve for foreign illegal labor to U.S. occupations.

The results for the SR simulation are almost completely unaffected by changing the slopes of the labor supply curves. In Table 6.7, the USAGE-M long-run deviation for consumption by legal households in the SR simulation moves from -0.52 per cent to

Figure 6.2. Borjas diagram for SR simulation: effect of increasing demand parameters

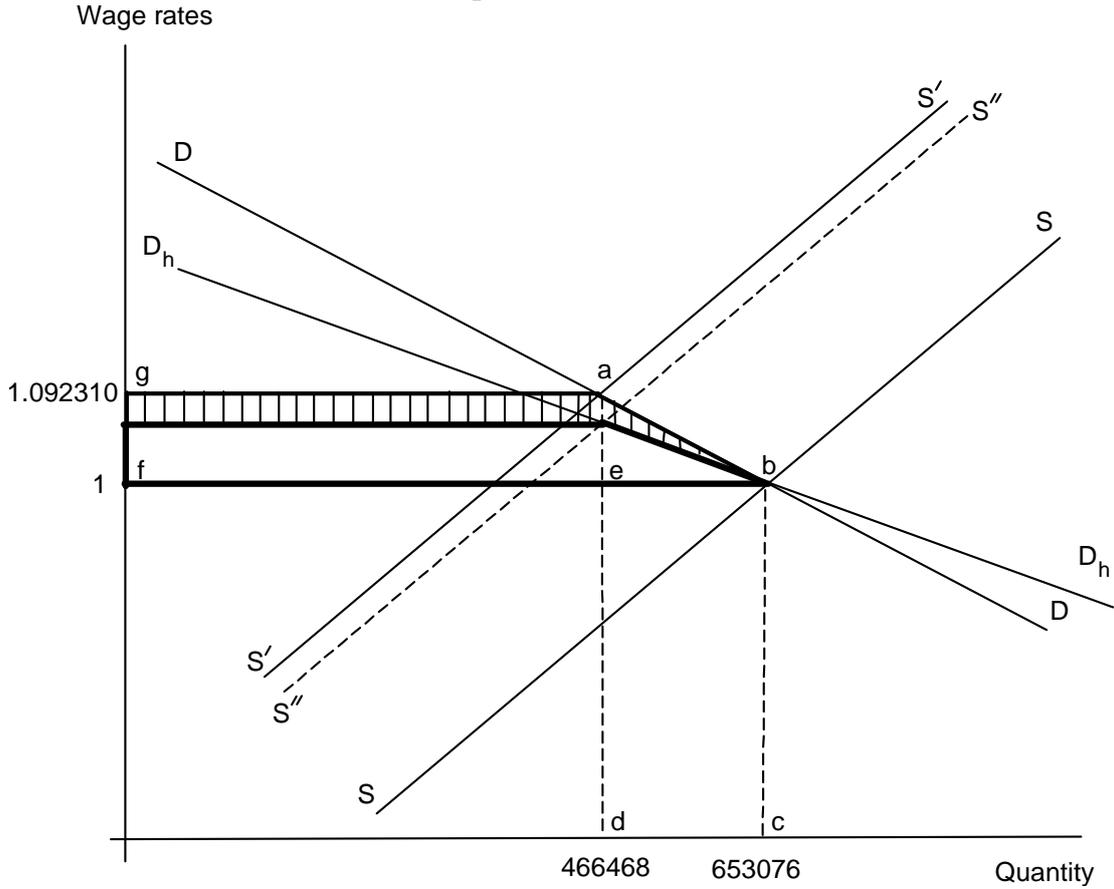
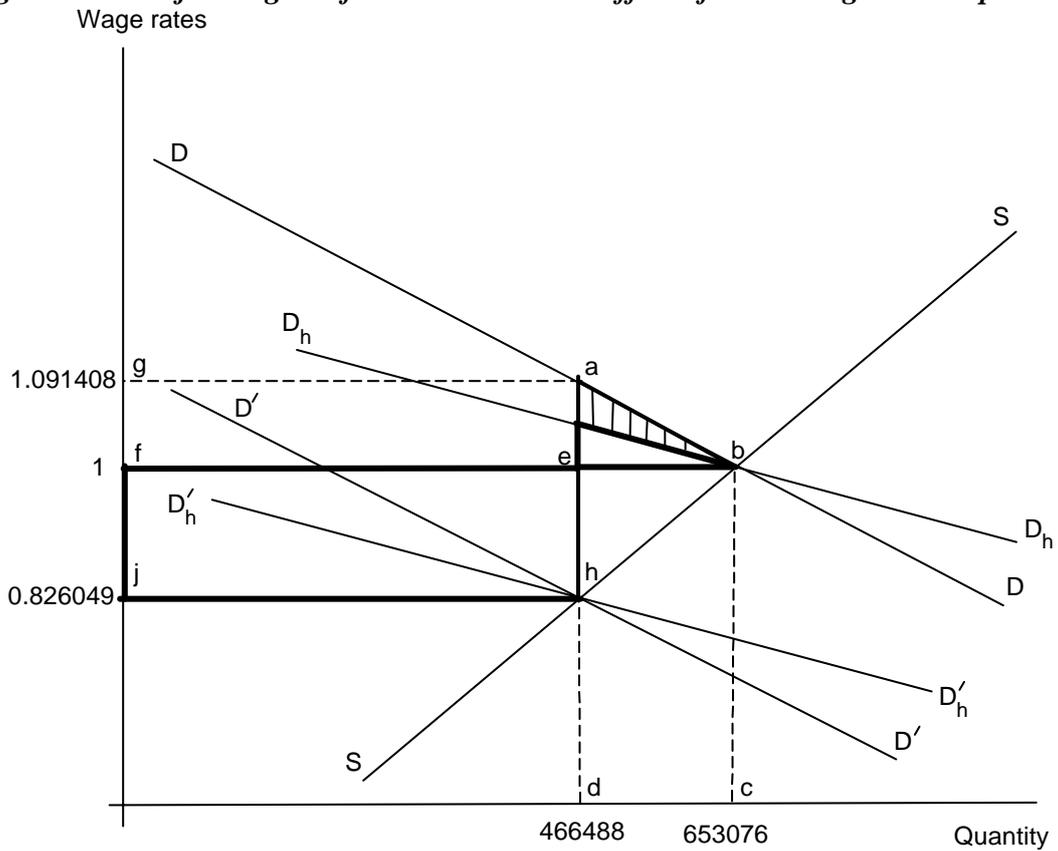


Figure 6.3. Borjas diagram for DR simulation: effect of increasing demand parameters



*Table 6.6. Varying demand parameters: SR and DR
percentage deviation results for consumption by legal households in 2019*

| | | SR simulation | | DR simulation | |
|-----------------------------|--|-----------------|-------------------|-----------------|-------------------|
| | | $\sigma_2= 5.0$ | $\sigma_2= 7.5$ | $\sigma_2= 5.0$ | $\sigma_2= 7.5$ |
| | | $\sigma_3= 7.5$ | $\sigma_3= 11.25$ | $\sigma_3= 7.5$ | $\sigma_3= 11.25$ |
| | | (1) | (2) | (3) | (4) |
| F1 | Direct illegal labor effect | -0.29 | -0.25 | 0.12 | 0.14 |
| F2 | Occupation mix effect | -0.31 | -0.32 | -0.31 | -0.32 |
| F3 | Capital effect | -0.24 | -0.24 | -0.18 | -0.18 |
| F4 | Legal employment effect | -0.11 | -0.11 | -0.10 | -0.10 |
| F5 | Public expenditure effect | 0.17 | 0.17 | 0.17 | 0.17 |
| F6 | Terms-of-trade and other macro price effects | 0.23 | 0.23 | 0.25 | 0.25 |
| Back-of-the-envelope totals | | -0.55 | -0.52 | -0.05 | -0.05 |
| USAGE-M result | | -0.52 | -0.50 | -0.08 | -0.08 |

*Table 6.7. Varying supply parameters: SR and DR
percentage deviation results for consumption by legal households in 2019*

| | | SR simulation | | DR simulation | |
|-----------------------------|--|---------------|--------------|---------------|--------------|
| | | $\eta = 2$ | $\eta = 1.5$ | $\eta = 2$ | $\eta = 1.5$ |
| | | (1) | (2) | (3) | (4) |
| F1 | Direct illegal labor effect | -0.29 | -0.30 | 0.12 | 0.20 |
| F2 | Occupation mix effect | -0.31 | -0.30 | -0.31 | -0.30 |
| F3 | Capital effect | -0.24 | -0.24 | -0.18 | -0.17 |
| F4 | Legal employment effect | -0.11 | -0.10 | -0.10 | -0.09 |
| F5 | Public expenditure effect | 0.17 | 0.17 | 0.17 | 0.17 |
| F6 | Terms-of-trade and other macro price effects | 0.23 | 0.24 | 0.25 | 0.26 |
| Back-of-the-envelope totals | | -0.55 | -0.54 | -0.05 | 0.07 |
| USAGE-M result | | -0.52 | -0.51 | -0.08 | 0.02 |

-0.51 per cent. The DR results are relatively more sensitive to changes in the slopes of the labor supply curves, with the long-run consumption deviation of legal households moving from -0.08 per cent to 0.02 per cent as η moves from 2 to 1.5.

As with the demand parameters, we had no prior reason to expect factors F2 to F6 in the explanation of the long-run consumption result for legal households to be affected by a change in η . This expectation is confirmed in Table 6.7. To analyze factor F1, we drew Figures 6.4 and 6.5. In Figure 6.4 the supply curve for foreign illegal labor with the original η value is SS. With the lower value, the supply curve becomes $S_L S_L$. The SR shocks with the original value move the supply curve from SS to $S'S'$. With the lower η value, the shocks move the supply curve from $S_L S_L$ to $S'_L S'_L$. On the basis of Figure 6.4, we would expect factor F1 to be unaffected by the change in η : the slope of the supply curve is irrelevant when we are imposing a shift in supply to cause a given reduction in foreign illegal employment. Consistent with Figure 6.4, the response of F1 to the change in η in the SR simulation is negligible.

In Figure 6.5, the DR simulation with the lower η value requires a shift in the demand curve from DD to $D''D''$ rather than to DD' . As we lower η , we would expect the DR simulation to generate an increase in F1, equal to the striped rectangle in Figure 6.5. From Table 6.7, we see that F1 increases from 0.12 per cent to 0.20 per cent as η moves from 2 to 1.5. This increase in F1 explains most of the increase in the USAGE-M result for the long-run deviation in consumption by legal households.

7. Concluding remarks

Our results have already been fully summarized at the start of the paper. Our main conclusion is that policies to limit employment of illegal migrants should have a significant focus on taxing and fining employers. Policies that concentrate solely on criminal prosecution of employers or on cutting inflows through tighter border security and deportations impose significant losses on the economic welfare of legal residents. To understand this conclusion, we need to recognize that any limitation policy will raise costs to the employers of those foreign illegals who remain in the U.S. However, policies differ with respect to the nature of these extra costs. In the case of taxes and fines, the extra costs are a transfer to the U.S. Treasury which is then able to improve the welfare of legal residents through tax cuts or increased public spending. In the case of discouragement of entry via tighter security and deportations, the extra costs are generated by an increase in the wage rates of the remaining foreign illegals, with no benefit to the legal residents. In the case of criminal prosecutions, the extra costs are likely to be a dissipation of real resources through the use of lawyers, accountants and other professionals involved in defending charges and mitigating their effects.

In generating our results we used a detailed CGE model. This enabled us to quantify two readily anticipatable effects of policies to limit illegal employment:

- *the direct illegal labor effect.* This refers to changes in producer surplus. As illustrated in sections 4 to 6, it can be analyzed effectively via Borjas diagrams showing demand and supply for illegal labor.
- *the public expenditure effect.* Cuts in employment of foreign illegals will reduce the number of these people and their dependents in the U.S., allowing reductions in public expenditures on schools, emergency medical assistance and correctional services. This will benefit legal residents. The public expenditure effect is prominent in political discussions. However, our quantification indicates that its importance may be over blown.

Figure 6.4. Borjas diagram for SR simulation: effect of decreasing the supply parameter

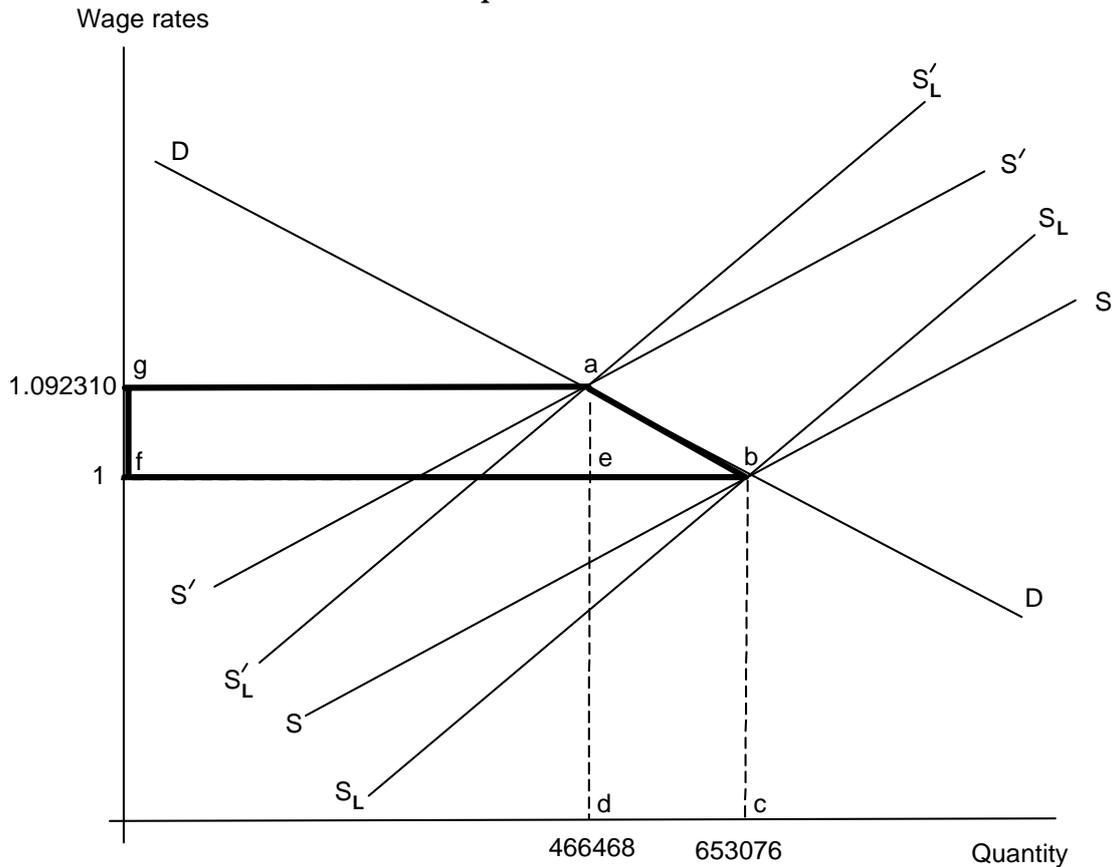
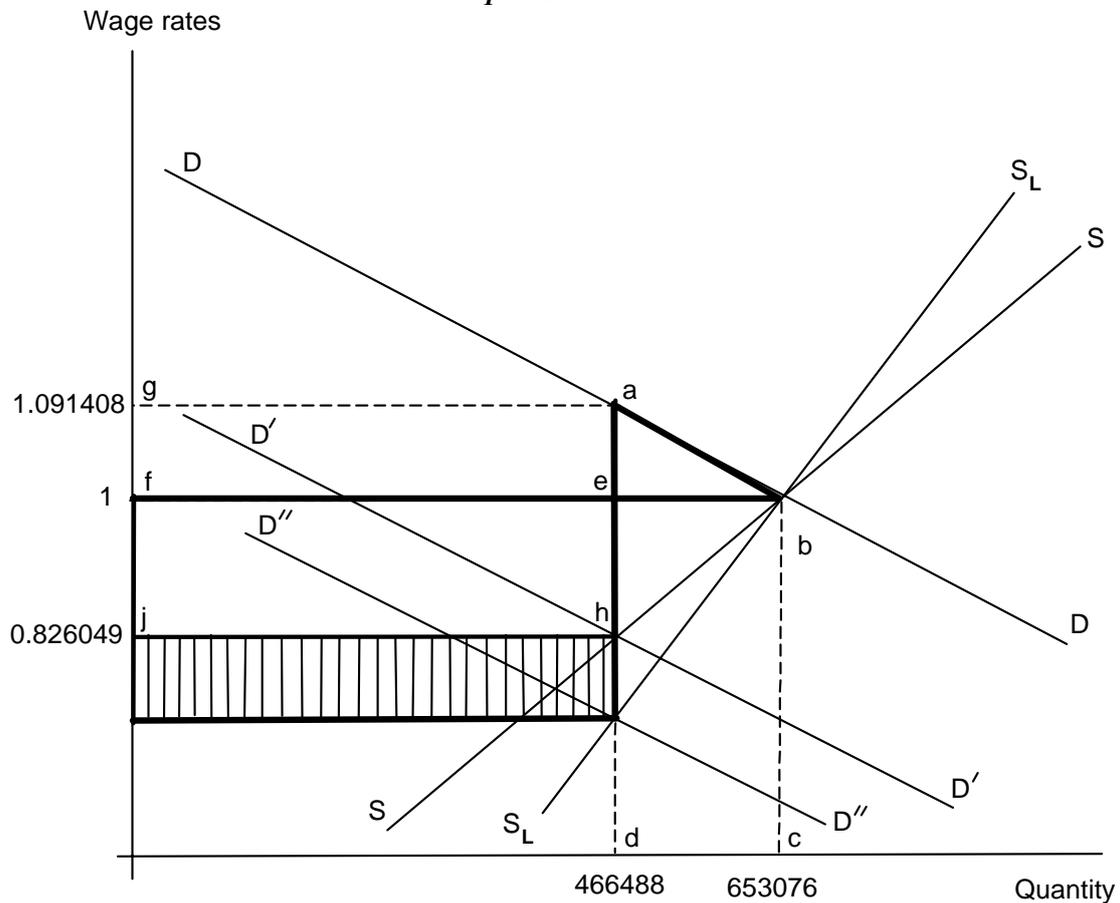


Figure 6.5. Borjas diagram for DR simulation: effect of decreasing the supply parameter



A strength of the CGE approach is that it allows us to go beyond readily anticipatable effects. CGE simulations with well-constructed, detailed models often identify effects that were initially unanticipated but, once identified, are believable, significant and explainable. Examples in the present study include:

- *the occupation-mix effect.* Cuts in foreign illegal employment will reduce the welfare of legal residents by lowering the average skill-level of their employment.
- *the capital effect.* With a smaller economy resulting from reduced foreign illegal employment, the U.S. will have a smaller capital stock, largely accommodated by reduced foreign investment in the U.S. This generates a welfare cost to legal residents through a loss of tax revenue on foreign-owned capital. Our simulations also show reduced saving by legal residents generating a further long-run loss in welfare via reduced domestic ownership of capital.
- *the legal employment effect.* Following from the occupation-mix effect, our simulations show a small long-run reduction in aggregate employment of legal residents. In macroeconomic terms, this is an increase in the NAIRU²⁶. It arises from a component of our database that shows higher levels of unemployment for low-skilled occupations than for high-skilled occupations.
- *the terms-of-trade effect.* With a smaller economy, the U.S. will have lower exports and imports. This will be a welfare benefit to legal residents because it will improve the U.S. terms of trade (the ratio of export prices to import prices).
- *the dominance of macro effects in determining industry outcomes.* Deviations in industry outputs caused by cuts of the number of foreign-illegal workers are largely independent of the current reliance of industries on these workers. Instead, these deviations reflect macro effects such as movements in investment and the exchange rate.

While the modeling reported in this paper identifies and quantifies many interesting effects, there is clearly room for significant improvements and extensions. An obvious improvement that could be undertaken in future work is the introduction of the implementation costs of policies.²⁷ Our present analysis omits these costs, thereby understating the welfare loss to legal residents of programs to reduce illegal employment. Although our results strongly indicate a preference for taxes and fines, a complete analysis would require comparison of the implementation costs of taxes and fines with those associated with enhanced border security and criminal prosecutions. Extensions of our analysis could be made in two directions: deepening and broadening. The present results could be deepened by extending them to variables describing the distribution of income across households and the allocation of economic activity across regions. The analysis could be broadened by considering other approaches to the illegal migrant issue such as legalization and amnesty.

Creation and application of CGE models such as USAGE-M requires sophisticated theoretical specifications, many pages of computer code and years of work on industry, trade and occupational data. It is not practical for consumers of CGE analyses to be familiar with these aspects. Fortunately, this is not necessary. As illustrated in this paper, even complex CGE analyses can be elucidated by back-of-the-envelope (BOTE) calculations. These calculations highlight the assumptions, data items and parameter values that are important in determining the principal results. In this way,

²⁶ Non-Accelerating-Inflation Rate of Unemployment.

²⁷ Implementation costs are emphasized by Hanson (2007).

they also provide guidance for future research. For example, the BOTE calculations in this paper indicate that important data items in determining the results include: the number of foreign illegal workers in each occupation; the wage rates of these workers relative to those of legal workers; and the income tax rates applying to the wages of illegal workers. Considerable payoff in terms of improved reliability of the results could be anticipated from further statistical work on these items. On the other hand, the BOTE calculations in section 6 indicated that econometric work on demand and supply elasticities for illegal migrants would have relatively little payoff in answering questions about the welfare implications for legal residents of programs to limit illegal employment.

A reaction of some economists to a successful set of BOTE explanations of CGE results is to question the need for the detailed CGE model. However, our experience in this and other projects suggests that it is the work undertaken to understand results from the detailed model that exposes previously unanticipated but ultimately simple and convincing mechanisms.

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