Immigration reform scenarios for U.S. agriculture

Peter .B. Dixon and Maureen T. Rimmer

Centre of Policy Studies, Victoria, Australia

March 16, 2016

Acknowledgements: We thank the U.S. Department of Agriculture for financial support under a co-operative agreement with Victoria University. We thank Peter Feather, who led the project, for perceptive and patient encouragement; and Steven Zahniser and Tom Hertz for valuable, constructive comments on an earlier draft. None of these people nor the USDA is responsible for the analysis or opinions expressed in the article.

Contact author: Peter B. Dixon
Centre of Policy Studies, Victoria University
300 Flinders Street , Melbourne, 8001, Australia

Ph: +613 9919 1464
Email: Peter.dixon@vu.edu.au

Immigration reform scenarios for U.S. agriculture

Abstract: The general equilibrium method adopted here reveals several effects of agriculture-focused immigration policies that would not have emerged in partial equilibrium analysis applied to agriculture. Our general equilibrium model includes specifications of: inter-sectoral labor flows; the role of vacancies in determining occupational choices; and macroeconomic relationships. This enables us to show that agricultural guest-worker and legalization programs are likely to: have similar effects on the agricultural sector; cause a gradual welfare-enhancing transformation of the occupational mix of incumbent employment away from agriculture; have small (possibly negative) effects on farm income; and have positive effects on aggregate capital, employment and GDP.

Key words: U.S. immigration, guest-worker program, legalization program, computable general equilibrium modeling, farm income

JEL codes: C68; J61, J62, J63, Q1

Policy on illegal immigration is a major topic in the U.S. political debate. There is universal agreement that the present situation, with between 6 and 8 million people working illegally in the U.S., is unsatisfactory. Reform proposals debated in Congress and its committees in recent years range across guest-worker programs (e.g. H.R. 1773, a guest-worker program for agriculture), legalization programs (e.g. S. 744) and programs for strengthening border protection and intensifying prosecutions (e.g. H.R.

2278). However, it has not been possible to reach sufficient political consensus to achieve worthwhile reform.

The main aim of this article is to contribute to the policy debate by providing quantitative analysis of the effects on the U.S. economy of guest-worker and legalization programs in agriculture. The special attention on agriculture in the policy debate (and consequently in this article) is justified because approximately half the hired workers in agriculture are illegal. This gives an exaggerated impression of the reliance of agriculture on illegal workers. Over half of the labor input to agriculture is provided by farmers and their families (all legal workers). Consequently only about a quarter of agricultural labor is illegal, which is, nevertheless, a higher level of dependence on illegal workers than for any other sector.[1]

In our analysis we use a computable general equilibrium (CGE) model with sufficient detail to adequately represent the salient features of policies directed at illegal immigrants. This detailed CGE approach sets our contribution apart from the bulk of U.S. immigration research which is dominated by partial-equilibrium econometric studies dealing with immigration as a whole (combined legal and illegal). Prominent examples of these studies are: Borjas (1994) on the performance of immigrants *in* the U.S. economy; and Borjas (1999 & 2003), Borjas, Grogger and Hanson (2008 and 2010), Card (2005), and Ottaviano and Peri (2006) on the effect of immigrants *on* particular aspects of the economy such as wages of low-skilled workers. Examples of partial-equilibrium studies with a specific focus on illegal immigration are: Espenshade (1994), Hanson and Spilimbergo (1999 & 2001), Kossoudji (1992) and Reyes (2004) concerned with the effects *on* illegal immigrants of policy interventions such as heightened border security; and Rector and Kim (2007) and Strayhorn (2006)

concerned with the public sector budgetary implications of illegal immigrants. Apart from allowing us to consider the effects of specific policy programs on a wide range of variables, the general equilibrium approach has another significant advantage relative to partial methods. It reveals channels not available in partial analysis through which immigration policies affect key variables including the welfare of farmers and the welfare of U.S. incumbents[2] more generally. We return to the issue of general versus partial in the final section.

The CGE model that we use to elucidate the effects of agricultural guest-worker and legalization programs is USAGE (U.S. Applied General Equilibrium). Features of USAGE relevant to the present study are explained in the next section. This is followed by our analyses of guest-worker and legalization programs. Under the guest-worker program, we assume that farmers are able to supplement the supply of agricultural labor by recruiting foreign guest workers who are not permitted to flow out of agriculture to other parts of the U.S. economy. These workers stay temporarily in the U.S. and then return home, to be replaced by other guest workers. Under the legalization program we assume that illegal workers currently in agriculture are given legal status on condition that they stay in agriculture for a specified period, after which they are free to move to other parts of the economy. We assume that guest and legalized workers receive higher hourly wage rates than illegal workers. Under the assumption that wage differences reflect productivity differences, our simulations give results for the two programs that are broadly similar. Both programs: reduce the cost to farmers of a unit of labor[3]; increase overall farm employment and output; reduce farm-gate prices and food prices; increase economy-wide employment; reduce employment of incumbents as agricultural workers; and improve incumbent welfare.

One contentious result that emerges from the two simulations is that reductions in unit labor costs may not increase farm income. We trace this possibility to the fact that a considerable fraction of farm income is farmer-supplied labor that is competitive with hired agricultural labor.

The final section contains concluding remarks together with a brief investigation of the proposition that the heavy dependence of agriculture on illegal workers justifies special programs to shield the sector from the adverse effects of tighter border security. We simulate a border security policy that reduces the supply of illegal labor to the economy by about 30 per cent. We find that such a policy would not reduce the size of the agricultural sector relative to the size of the U.S. economy, nor would it harm U.S. food security measured by the agricultural balance of trade (U.S. agricultural exports compared with agricultural imports). However it would cause a significant reduction in farm income.

The USAGE model

USAGE (U.S. Applied General Equilibrium) is a dynamic, CGE model of the U.S. economy. It is a flexible model and has been applied by policy sections in the U.S. International Trade Commission and the Departments of Commerce, Agriculture, Homeland Security, Energy and Transportation in studies concerned with import restraints, immigration and several other topics [see Dixon, Koopman and Rimmer (2013) for an overview]. The flexibility of USAGE is enhanced by the ability to change its industry/commodity classification from application to application. The version used in this article focuses on agriculture: it has 16 agricultural industries and 53 other industries.

The features that USAGE shares with most other single-country CGE models are that: industries and capital creators choose intermediate and primary factor inputs to minimize the costs of supplying any given amounts of output and new capital subject to constant-returns-to-scale production functions with CES nests; households choose their consumption bundle to maximize utility subject to factor incomes plus transfers less taxes; all agents treat domestic and imported varieties of any commodity as imperfect substitutes in the fashion of Armington (1969); exporters face downward sloping demand curves for their products; commodity and factor prices in each period are determined by the interaction of demand and supply; the quantity of capital created for each industry responds to expected rates of return formed using either forward-looking or static specifications; and the economy evolves from period to period driven by capital accumulation and exogenously given paths for incumbent population, technology, consumer preferences, world trading conditions and policy objectives.

For understanding this article, there are two possibly unfamiliar aspects of USAGE of which readers need to be aware. The first is that a simulation of the effects of a policy shock requires two runs of the model: a baseline or business-as-usual run and a policy run. The baseline run is intended to be a plausible forecast, while the policy run generates deviations away from the forecast caused by the policy under consideration. For this article, the policies encapsulate guest-worker and legalization programs for agriculture. For the most part, we report the effects of policies as percentage deviations in variables (such as wage rates and employment) away from their baseline paths.

The second non-standard aspect of USAGE is the treatment of the labor market. Here we give a relatively brief non-technical description that we hope is adequate for

following our analyses in later sections. For a longer more mathematical description see Dixon and Rimmer (2010).

On the demand side of the labor market, we assume that each industry chooses a combination of workers in different activities to minimize the wagebill cost of satisfying its labor requirements. These requirements are specified as nested CES functions of inputs of 200 labor activities (o,b,s) defined by 50 occupations (o), two birth places (b, domestic and foreign) and two legal statuses (s, legal and illegal). We assume low substitutability between occupations in the top nest and high substitution between birth places and between statuses in lower nests. Thus, plumbers and agricultural workers are poor substitutes, legal and illegal agricultural workers are good substitutes, as are (agricultural worker, domestic, legal) and (agricultural worker, foreign, legal,).[4]

On the supply side, at the start of year t people in different categories make offers to work during year t in the 200 activities. The categories are defined mainly on the basis of labor-market activity in year t-1. The categories include: employed as (o,b,s) in year t-1, unemployed in t-1, and employed outside the U.S. in t-1. This last category is relevant for the present study because people outside the U.S can offer to work in U.S. occupations as foreign illegals. We also include a category of new entrants fed by school and college leavers and other people joining the labor force.

People in each category decide their offers to labor-market activities via an optimization problem. These problems take into account wages in each activity and the particular category's skills and characteristics. Through the optimization problems we ensure that people make offers only to activities compatible with their skills and characteristics: people in an unskilled category make few offers to skilled activities;

people in a category with the characteristic "foreign" make no offers to activities with the characteristic "domestic"; and people in a category with the characteristic "illegal" make no offers to activities with the characteristic "legal". The optimization problems are set up so that people in the (o,b,s) category make most of their offers to the (o,b,s) activity, that is they plan to continue in year t with the type of employment they had in year t-1. However, they can be induced to switch some of their offers to other compatible activities if wages in these activities rise relative to those for (o,b,s).

Deaths and retirements are handled via the specification of transitions from activities undertaken in year t-1 to categories at the beginning of year t. For example, if the rate of deaths and retirements is one per cent and there were 100 people employed as (plumber, domestic, legal) in year t-1, then the number of people in category (plumber, domestic, legal) at the beginning of year t will normally be 99. For this article it is also relevant to note that a legalization policy can be introduced through a transition specification that takes people who were in activity (o, foreign, illegal) in year t-1 into category (o, foreign, legal) at the beginning of year t.

We assume that offers (supplies) to any activity (o,b,s) exceed demands: not everyone who offers to (o,b,s) finds employment in that activity. Our model includes a set of rules for what happens to people whose offers are not accepted: the unemployed stay unemployed; people offering to (o,b,s) from another category stay employed in their original activity[5]; and people offering to (o, foreign, illegal) from outside the U.S. stay in their home country. If demand for (o,b,s) increases relative to supply, then (o,b,s) wage rates rise, damping demand and stimulating supply. But wage adjustment is sluggish. An increase in the demand/supply ratio for (o,b,s) opens up vacancies, increasing the likelihood of acceptance of offers from outside (o,b,s). This has a ripple

effect through the labor market. With more offers to (o,b,s) being accepted, vacancies open up in other activities, improving the likelihood of acceptance of other inter-occupational offers.

Guest-worker program

In each of the years 2015, 2016 and 2017 we assume that 100,000 guest workers are assigned to the occupation Miscellaneous agricultural worker (MAW). This occupation accounts for nearly all of the hired labor in the agricultural sector.[6] From 2018 until 2025 (the end of the simulation period), we assume that the guest worker program is designed to maintain the number of guest workers in MAW at 300,000. Consistent with proposals of the type included in S744, we assume that guest workers must stay in agriculture. They are never eligible to move to other industries and occupations. When they leave the U.S. they are replaced by other guest workers.

Figures 1 to 7 and table 1 give USAGE results for the effects of the guest-worker program on macro and agricultural variables. All results are in deviation form, that is, they show how different a variable's value is with the guest-worker program in place (policy run) from its value without the program (baseline run).

Aggregate employment

With baseline employment in 2025 being 164 million, we might expect that a 300,000 guest-worker program would increase U.S. employment (measured in people) by 0.18 per cent [= 100*(300,000)/164m]. However the USAGE result in figure 1 is an increase of only 0.16 per cent (255 thousand). The discrepancy is explained mainly by a reduction in foreign illegal inflow.

While it is not surprising that the guest-worker program reduces foreign-illegal inflow, the modest extent needs explaining. The total inflow of illegal workers

depends on average wages and employment opportunities available to these workers in the U.S. compared with wages and opportunities in their own countries. Using a guest-worker program to crowd out foreign-illegal employment in just one sector, agriculture (which accounts for about 8 per cent of illegal employment), has only a minor effect on average wages and opportunities available to illegal workers. As will become clear, to a large extent the economy-wide illegal inflow is maintained with illegal workers making a shift away from MAW to other occupations.

In wagebill terms, figure 1 shows an increase in employment in 2025 of 0.12 per cent. The wagebill measure adds up percentage changes in employment by occupation, industry, birth place and legal status with weights that reflect wage rates, as well as numbers of people employed. With this measure, an increase in employment by one job in a high-paid category contributes more to employment than an increase in employment by one job in a low-paid category. The wagebill measure is relevant for understanding the contribution of an increase in employment to GDP. It is the measure of labor input commonly used in aggregate production functions that relate GDP to factor inputs and technology.

With the influx of people to the U.S. workforce being low-paid MAW guest workers, it is understandable that the employment increase measured in people (0.16 per cent) exceeds the employment increase measured in wagebill units (0.12 per cent). At first glance, however, the difference between these two measures doesn't seem large enough: the average wage of MAW workers is only about a quarter of the average wage over all U.S. workers.

The influx of MAW guest workers causes an *occupational-mix effect*. The occupational mix of the rest of the U.S. workforce adjusts towards higher paid

occupations. This limits the gap between the people and wagebill measures of the aggregate employment effect of the guest-worker program. The occupational-mix effect arises as follows. The influx of MAW guest workers increases the size of the U.S. economy. This increases employment in all occupations. Vacancies open up in all occupations except MAW. Thus, new entrants to the U.S. labor force and people returning from periods out of work are confronted with a reduction in vacancies in MAW but an increase in vacancies in all other occupations. This tilts the mix of employment for workers who are not part of the guest-worker program away from MAW towards other occupations. Because MAW is low paid, this change in the occupational mix of people outside the guest-worker program has a positive effect on the wagebill measure of employment, muting the overall fall in the ratio of wagebill employment to people employment.

Capital and GDP from the income side

As shown in figure 1, the guest-worker program causes the U.S. capital stock to grow relative to baseline throughout the simulation period. By 2025, the deviation in the capital stock is 0.09 per cent. This is a little below the deviation in labor input of 0.12 per cent. In the long run we might expect the deviations in capital and labor to be approximately the same. This is because we assume that the influx of guest workers does not affect either technology or the long-run equilibrium rate of return on capital. However we have not reached the long run in 2025: the capital deviation is still rising. Nevertheless, it is clear that even if the simulation were continued, the capital deviation would remain slightly below the labor deviation. The explanation is the inclusion in our model of agricultural land. With returns to capital fixed in the long-run,

diminishing returns imparted by fixed land mean that K/L falls in the long run when L increases. [7]

The sluggish adjustment of capital lies behind the sluggish adjustment of employment shown in figure 1. The employment deviations build up gradually to the long-run values of 0.16 per cent and 0.12 per cent even though the guest-worker program is fully implemented by 2017. Guest workers have a short-run displacing effect on existing workers, lowering employment of incumbents and net inflow of illegal workers. Eventually, with capital and wage rates adjusting, there is a complete recovery in incumbent employment and a partial recovery of net illegal inflow.

The deviation in GDP in 2025 is 0.11 per cent. This can be explained by the equation:

(1) $\quad gdp = a + S_L * \ell + S_K * k$

where

gdp, ℓ and k are the percentage deviations in GDP, labor input and capital;

a is the percentage deviation in total factor productivity; and

S_L and S_K are the labor and capital shares in GDP.

With *a* assumed to be zero, S_L and S_K equal to 0.65 and 0.35, and ℓ and k equal to 0.12 and 0.09, equation (1) gives gdp as 0.11.

GDP from the expenditure side

Figure 2 shows deviation paths for the expenditure components of real GDP (Y): private consumption (C), investment (I), public consumption (G), exports (X) and imports (M). Imports and private consumption follow quite closely the path of GDP. Public consumption increases relative to private consumption and GDP. In percentage terms, guest workers increase demands for public services to a greater extent than they

increase demands for private consumption in the U.S. Investment is strongly stimulated in the first half of the simulation period reflecting the adjustment of the capital stock (slope of the capital deviation line in figure 1). With the deviations in C and M being approximately the same as those in Y, and with the deviations in G and I being well above those in Y, the deviations in X must be below those in Y. Elevated investment and public expenditure appreciate the U.S. real exchange rate (reduces U.S. international competitiveness) facilitating the required reduction in exports relative to GDP.

Consumption and welfare effects for incumbents

A critical question is: how does the guest-worker program affect the welfare of incumbents?

In the policy run we allow the average propensity to consume to adjust so that the path of real national savings is the same as that in the baseline. This means the deviation path shown in figure 3 for consumption of incumbents is a legitimate indication of the effects of the guest-worker program on incumbent welfare.

By the end of the simulation period, incumbent consumption (or welfare) is increased by 0.09 per cent, figure 3. As shown in the boxed table in figure 3, this can be explained approximately by six contributing factors. Detailed explanations of these factors and how they are calculated can be found in Dixon, Johnston and Rimmer (2011) and Dixon and Rimmer (2010).

The first factor (F1) is the *Direct effect*. It reflects changes in the cost to the U.S. of labor supplied by non-incumbent workers. The guest-worker program can be thought of as an increase in the supply of non-incumbent MAW labor. This reduces the cost of a unit of this labor (after-tax wage per unit). A unit might be an hour of labor by an

illegal worker or 50 minutes by a guest worker where the difference in time reflects greater productivity of guest workers relative to illegal workers. Reduction in the unit cost of non-incumbent MAW workers imparts a welfare gain to the incumbent economy. This is estimated as a welfare gain in our simulation of 0.020 per cent.

The second factor (F2) is the *Occupation-mix effect*. As discussed earlier, this arises from a favorable change in the occupational mix of incumbent employment. The table in figure 3 shows that the occupational-mix effect is the major source of welfare gain (0.043 per cent) for incumbents from our simulated guest-worker program.

The third factor (F3) is the *Capital effect*. As explained in the subsection on Capital and GDP, the guest-worker program leads to an increase in the U.S. capital stock. To a large extent, this is financed by foreigners. Nevertheless, the increase in capital stock produces a welfare gain for U.S. incumbents. This is because foreign owners of U.S. capital do not receive the entire marginal product of this capital. They pay U.S. taxes, conferring a welfare gain on U.S. incumbents. In our guest-worker simulation this is a welfare gain of 0.007 per cent.

The fourth factor (F4) is the *U.S. employment effect*. This refers to the welfare effect of changes in incumbent employment. Policies that stimulate incumbent employment (reduce involuntary unemployment) produce a welfare gain, a positive value for F4. We assume that the guest-worker program has no long-run effect on unemployment rates by occupation for incumbent workers: occupational wage rates adjust in the policy run to re-establish the baseline ratio between employment in each occupation and the supply of workers to the occupation. Nevertheless, the guest-worker program generates a small increase in incumbent employment. This result is a combination of two forces: one positive and one negative. The positive force arises from differences

across occupations in employment/labor-supply ratios. High-skilled occupations have higher ratios than low-skilled occupations. This is a positive force on incumbent employment in simulations, such as the current one, in which the mix of incumbent employment moves towards higher-skilled occupations. The negative force is that the guest-worker program biases competition to fill vacancies in MAW in favor of foreigners (guest workers with guaranteed jobs) and against U.S. incumbents. This leaves in unemployment some U.S. incumbents who, in the absence of the guest-worker program, would have filled MAW vacancies. As shown in the table in figure 3, F4 is positive, 0.007 per cent: the positive first effect outweighs the negative second effect.

The fifth factor (F5) is the *Public-expenditure effect*. Guest workers require public sector services. This imparts a welfare loss to the incumbent economy, estimated in the current simulation as 0.008 per cent.

The sixth factor (F6) is the *Macro-price effect*. This effect arises mainly from changes in the terms of trade (the price of exports relative to the price of imports). The guest-worker program increases the size of the U.S. economy. By 2025, this leads to an increase in U.S. exports, with a decrease in their world price, contributing a welfare loss of 0.004 per cent.

Disaggregation of labor-market effects

As we will see later in this subsection, the increase in the supply of MAW, via the guest-worker program, reduces the cost of employing MAW. This leads to a moderate increase in agricultural output (discussed below) with a correspondingly moderate increase in agricultural employment. Figure 4 shows that the guest-worker program

generates a long-run increase (2025) in employment of MAW of 1.93 per cent (or 62 thousand jobs, table 1, row g).

How does a 300-thousand-person guest-worker program translate into an increase of MAW employment of 62 thousand?

Non-incumbent employment of MAW expands sharply, 28.43 per cent by 2025 (figure 4) which is an increase of 177 thousand. As shown in rows c and f of table 1, this is made up of 300 thousand guest workers and a reduction in illegal workers of 123 thousand (19.63 per cent, figure 4). Lower wages and curtailed employment opportunities reduce the supply of illegal worker to MAW, explaining the fall in illegal employment in MAW. For the same reasons, the guest-worker program reduces employment for incumbent MAW, by 4.38 per cent (figure 4) or 115 thousand people (row e, table 1). The long-run percentage reduction for these workers (4.38 per cent) is less than that for illegal MAW (19.63 per cent). This reflects a lower supply elasticity of incumbent MAW (which includes inelastically supplied labor by farmers) than that for illegal MAW. As can be seen in table 1, when we put all these numbers together, the result for MAW employment is an increase of 62 thousand.

We model incumbent and non-incumbent MAW as highly substitutable from the point of view of employers. Nevertheless, by causing a sharp increase in the supply of non-incumbents, the guest-worker program generates a noticeable long-run reduction in the wage for a typical hour of non-incumbent labor relative to that of incumbent labor (5.50 per cent relative to 3.21 per cent, figure 5). Averaged across non-incumbent and incumbent labor using wagebill weights, the overall long-run reduction in MAW wages is 3.67 per cent.[8]

Despite the reduction in the wage rate for non-incumbents, figure 5 shows a positive deviation in the wage rate of guest workers in 2025, 1.68 per cent. This deviation is the guest-worker wage in policy relative to the wage rate in the baseline for illegal workers. The result that workers in the guest-worker program are better off than they would have been as illegal workers without the program reflects the productivity advantage that we assume for guest workers relative to illegal workers. We follow Bipartisan Policy Center (2013) and Treyz, Stottlemyer and Motamedi (2013) in assuming a productivity advantage for legal workers relative to illegal workers in the same occupation of between 6 and 12 per cent. MAW workers who remain illegal receive lower wages with the program than without it.

The reduction in the cost of MAW labor increases the profitability of investment in agriculture. Consequently, as can be seen figure 6, capital in agriculture grows. After the number guest-workers in MAW stabilizes in 2017, the continuing adjustment of the capital stock allows MAW wages to gradually recover, without reducing MAW employment (figure 4). The gradual recovery in MAW wages can be seen in figure 5. The percentage deviation in the average MAW wage rate increases from -4.97 in 2017 to -3.67 in 2025.

The middle panel of Table 1 is a decomposition of the effects of the guest-worker program on employment outside MAW. Row h repeats the information from row d: no guest workers flow out of MAW to the rest of the U.S. economy. Row i shows that incumbent employment in non-MAW increases by 131 thousand. This is calculated in rows j and k. It is the reduction in incumbent employment in MAW (115 thousand from row e) plus the *reduction* in incumbent unemployment of 15 thousand, row k (discussed above in relation to factor F4 in the determination of incumbent welfare).

The final item in the determination of non-MAW employment is the change in the number of non-MAW illegal workers (a rise of 63 thousand, row l): the reduction in wages and employment opportunities in MAW for illegal workers causes a flow of these workers out of MAW and into Non-MAW. The outflow in row f (123 thousand) exceeds the inflow in row l (63 thousand) for two reasons. First, some illegal MAW return home and second there is a reduction in net supply to Non-MAW from outside the U.S. reflecting greater competition for illegal Non-MAW jobs. In total, non-MAW employment increases by 193 thousand.

The final two rows in Table 1 show the effect of the guest-worker program on total employment as an addition of MAW and non-MAW employment.

Other agricultural variables

As shown in figure 6, the reduction in the cost of MAW workers leads to a reduction in the farm-gate prices of agricultural products (0.47 per cent in 2025) with a muted reduction in food prices (0.10 per cent in 2025). The reduction in farm-gate prices leads to a long-run expansion of exports of agricultural products (0.85 per cent) and contraction in imports (0.99 per cent). Output of agricultural products increases by 0.47 per cent. Supporting the increase in agricultural output are increases in inputs of capital and labor. We assume that land-input for the agricultural sector is unaffected by the guest-worker program. However, we allow land to be shifted between different agricultural activities.

Apart from capital and output, the paths for all variables in figure 6 show deviations that gradually decline in absolute terms beyond 2017. This reflects the upward movement after 2017 in the average cost of MAW labor shown in figure 5. The capital deviation increases throughout the simulation period as capital adjusts sluggishly to the

sustained increase in the profitability of agricultural investment. Despite the positive slope of the import deviation path and the negative slope of the export deviation path, agricultural output increases slightly beyond 2017. This reflects the continuing increase in private consumption (figure 2), which is explained largely by increasing employment (figure 1) and population (partial recovery of illegal inflow, mentioned in the subsection on capital and GDP).

Figure 4 showed a long-run increase in MAW employment of 1.93 per cent. The number shown in figure 6 for the long-run increase in labor input to agriculture is only 1.05 per cent. There are two reasons for the difference. First, MAW employment is not all of agricultural employment. It accounts for about 80 per cent of the value of labor input to agriculture. The guest-worker program causes a slight reduction in non-MAW employment in agriculture via a substitution effect: MAW labor becomes cheap relative to non-MAW labor. Second, the measure shown in figure 4 is people whereas that in figure 6 is labor input (a wagebill weighted measure). The guest-worker program boosts people employment in agriculture more than labor input because the guest workers have lower productivity than the incumbent MAW and non-MAW labor that they replace.

The main point about the increase in agricultural employment, whether measured in people or labor input, is its small size. This is for a program that adds 300 thousand guest workers to agriculture, about 9 per cent of agricultural employment. The introduction of guest workers crowds out other suppliers of agricultural labor, leaving the net increase in agricultural employment at one or two per cent. Because the effect of the guest-worker program on agricultural employment is small, its effect on the other variables shown in figure 6 must also be small.

Farm income

Farmers and their families provide more than half the labor input in U.S. agriculture. As shown in figure 7, the simulated effects of the guest-worker program on real farm income depend on what assumption is made concerning the nature of farmer labor. If we assume that farmers supply only MAW labor then the guest worker program has a negative effect on real farm income throughout the simulation period. On the other-hand , if we assume that farmer labor is only 35 per cent MAW, with the other 65 per cent being management services which are complementary with the input of land, then the guest worker program has a positive effect on real farm income for all years beyond 2016 - - the effects in 2015 and 2016 are very small negatives. Intermediate results are obtained when the MAW share in farmer labor is assumed to be 50 per cent.

To understand these results, especially the counterintuitive possibility of negative effects, we need to be clear about the definition of real farm income. We define real farm income as farm income deflated by the CPI. Farm income is returns to farm factors: farm land and capital *plus* the value of farmer labor supplied to the sector. [9] In our modeling, *x* per cent of farmer labor is valued at the wage of legal domestic MAW where *x* is the per cent of farmer labor that we assume is MAW (100, 50 and 35 in the central guest-worker simulation and the two sensitivity simulations shown in figure 7). The remaining percentages (0, 50 and 65) are treated as part of land. In effect, the wages paid to these fractions of farmer effort are proportional to the rental value of land. Policies (such as a guest-worker program) that make land more valuable, increase the wage of the management fraction of farmer labor.

How can an increase in the availability of MAW and a consequent reduction in the average cost of MAW labor (3.67 per cent in 2025, figure 5) reduce farm income?

One way to understand this possibility is by studying the stylized model depicted in figure 8. In this model, output is produced by a variable factor and a fixed factor. The variable factor can be thought of as MAW labor. The fixed factor can be thought of as an amalgam of land, capital and farmer supplied management services.

In either the top or bottom diagrams in figure 8, AD_0D_1 shows the value of the marginal product of labor in agriculture defined as:

$$\text{(2)} \qquad VMPL = P * \frac{\partial Q}{\partial L}$$

where

P is the price of output[10];

Q is the quantity of output; and

L is the input of the variable factor, labor.

VMPL is a declining function of labor input for two reasons. First, $\partial Q/\partial L$ declines as more labor is applied to a given amount of fixed factor. Second, P declines in response to the increase in output brought about by an increase in L.

AC_0E_1 shows the marginal revenue product of labor in agriculture defined as:

$$\text{(3)} \qquad MRPL = \frac{\partial (P * Q)}{\partial L} = P * \frac{\partial Q}{\partial L} + \frac{\partial P}{\partial L} * Q \qquad .$$

That is,

$$\text{(4)} \qquad MRPL = VMPL + \frac{\partial P}{\partial L} * Q$$

The second term on the RHS of (4) is negative. Consequently the MRPL line lies below the VMPL line (except when Q is zero).

In a sector such as agriculture with many small producers, it is reasonable to suppose that each producer ignores the effect on price of variations in his/her output.

Consequently, producers hire labor up to the point where wage equals VMPL. Thus, if the wage is initially B_0 then employment is initially L_0. Farm profits (returns to fixed factors: land, capital and farmer-supplied management)[11] in this situation are given in both diagrams in figure 8 by:

(5) $$\text{Profit}_o = \text{area}(AB_0C_0) - \text{area}(C_0D_0E_0)$$

The first triangular area on the RHS of (5) is profits made on units of labor up to the point where wage equals the marginal revenue product of labor. The second triangular area is losses made on units of labor past the point where wage equals the marginal revenue product. The sector incurs these losses because individual producers fail to account for reductions in prices as they expand employment and output.

Now assume that the wage falls from B_0 to B_1, perhaps in response to a guest-worker program. This causes employment to expand from L_0 to L_1. Looking at the top diagram in figure 8 we see that the effect on farm profits has three components. The first component is a profit increase of $B_0D_0FB_1$. This is the reduction in the cost of the initial labor input (L_0). The second component is a profit increase of E_0C_1F. This is profits made on extra units of labor up to the point where the lowered wage (B_1) equals the marginal revenue product of labor. The third component is a profit loss of $C_1D_1E_1$. This is losses made on extra units of labor beyond the point where the lowered wage equals the marginal revenue product. Thus the change in profits when wage falls from B_0 to B_1 is:

(6) $$\Delta \text{Profit} = \text{area}(B_0D_0FB_1) + \text{area}(E_0C_1F) - \text{area}(C_1D_1E_1) \quad .$$

This formula also applies in the lower diagram. It is apparent that the change in profit given by (6) can be either positive or negative.

An important ingredient in this argument is that the demand curve for agricultural products is downward sloping. If the demand elasticity were infinite (flat demand curve), the VMPL and MRPL curves would be coincident, implying that a reduction in MAW wages would unambiguously increase farm profits (returns to fixed factors). Realistically however, our guest-worker simulation shows a reduction in farm-gate prices (figure 6) as an outcome of the decrease in agricultural wages. In a competitive sector such as agriculture, facing product demand curves with comparatively low elasticities, a significant decrease in product price must be the outcome of a cost reduction.

The probability of a negative outcome is increased when we consider farm income instead of farm profits. Assume that in the initial situation the fraction α of agricultural labor (variable factor) is supplied by farmers and that all of the extra labor input is hired labor. Then, the change in farm income is:

(7) $$\Delta \text{Farm income} = \Delta \text{Profit} - \alpha * \text{area}(B_0 D_0 F B_1).$$

The second term on the RHS of (7) takes account of the reduction in the value of farmer-supplied MAW labor. Farmers benefit from paying lower wages to hired labor, but they do not benefit from paying lower wages to themselves. Putting (6) and (7) together gives:

(8) $$\Delta \text{Farm income} = (1-\alpha) * \text{area}(B_0 D_0 F B_1) + \text{area}(E_0 C_1 F) - \text{area}(C_1 D_1 E_1).$$

Recognition of α can substantially diminish the major positive term on the RHS of (8). Thus, even if a reduction in MAW wages increases farm profits, it may reduce farm income. In the guest-worker simulation in which we assume that the MAW percentage in famer-supplied labor is 100, α is 0.5, that is farmers supply half the farm sector's

variable labor input. When we assume that the MAW percentage in farmer-supplied labor is 50 per cent, α falls to 0.33, and when the MAW percentage is 35, α is 0.26. Correspondingly figure 7 shows increasingly favorable effects on farm income as we change our assumption concerning the MAW content of farmer labor from 100 to 50 to 35 per cent.

Given its importance in determining outcomes for farm income, it is worth trying to tie down a value for the MAW percentage in farmer-supplied labor. The Economic Research Service (ERS) has a rule of thumb that farmers provide management services worth 5 per cent of the value of production (Hoppe, MacDonald and Korb, 2010). Farmer-supplied labor (MAW plus management) is about 11 per cent of the value of agricultural production. Consequently, the ERS rule of thumb implies that management is about 45 per cent of farmers-supplied labor (= 100*0.05/0.11), or equivalently the MAW percentage in farmer effort is 55 per cent. On this basis, we see that the ERS rule of thumb would give a graph slightly lower than the 50% MAW graph shown in figure 7.

The final aspect of figure 7 requiring comment is the shape of the graphs. Why do they have a negative slope in the early years and then a positive slope in the later years with this shape being much more pronounced for 100% MAW than for 35% MAW? There are two explanatory factors. First, the initial reductions in the wage rates of MAW have a strong negative effect on real farm income for 100% MAW. As we move to 50% MAW this effect weakens and almost disappears when we reach 35% MAW (reflecting the reduction in α). This explains why the 100% MAW graph moves much lower than the graphs for 50% MAW and 35% MAW. Correspondingly, the recovery of MAW wages after 2017 (figure 5) has a strongly positive effect on real

farm income for 100% MAW, a weaker positive effect for 50% MAW and a negligible effect for 35% MAW. The second explanatory factor is the movement in the labor/capital ratio for the agricultural sector. Initially, the guest-worker program generates a sharp increase in L/K (figure 6). This effect is largely independent of what is assumed about the MAW content of farmer labor. As capital adjusts in the long run, part of the initial increase in L/K is whittled away. With K income accruing entirely to farmers and L income accruing only partly to farmers, the fall in L/K beyond 2017 gives a boost to real farm income in all three cases shown in figure 7.

Legalization program

The simulation described in this section illustrates the effects of a legalization program for illegal people currently employed in the U.S. as MAW. For each of the years 2015, 2016, 2017 and 2018 we assume that 25 per cent of the people employed in the previous year as illegal MAW are transitioned to legal status. The total number of people that are legalized in this process is 436 thousand. Beyond 2018 there are no further policy shocks. The simulated effects of the legalization program are shown in figures 9 to 15 and table 2.

Employment: aggregate and decomposition

Figure 9 shows that the legalization program raises aggregate employment in 2025 by 0.24 per cent in people terms and 0.21 per cent in wagebill terms. As with the guest-worker program, the people deviation exceeds the wagebill deviation because, as we will see, the extra employment is accounted for mainly by increased inflow of low-skilled, low-wage foreign workers.

Why should legalization of people already working in the U.S. as illegal MAW boost U.S. employment? The answer captured by USAGE is that legalization increases the

propensity of workers to flow out of MAW and into other occupations. This opens up vacancies in MAW and induces an inflow of illegal workers. In this way, total U.S. employment is increased in the long run.

Underlying this result are the following factors. First, as mentioned earlier in our discussion of the guest-worker program, we assume that legalization gives workers higher productivity and increases their potential wage rates in any occupation compatible with their skills. Second, legalization initially increases the effective supply of MAW labor. This reflects the increased productivity of the legalized MAW. Third, the increase in the effective supply of MAW labor limits the wage increase for legalized workers that stay in MAW and reduces the wages of incumbent workers in MAW. Together the first and third factors encourage a rapid flow of legalized MAW workers to other occupations. The third factor also encourages incumbents to leave MAW employment. Fourth, the flow of legalized and incumbent MAW workers to other occupations reduces wage rates in these occupations, allowing expansion in employment throughout the economy, not just in agriculture. Fifth, potential illegal workers outside the U.S. have a high propensity to supply their labor to MAW, and as legalized and incumbent MAW workers move to other occupations, new illegal workers come into the U.S. to fill the MAW vacancies. This produces an increase not only in non-incumbent MAW employment but also in total U.S. employment.

Table 2 shows that only 129 thousand (row c) of the 436 thousand legalized workers (row a) remain in MAW in 2025. Of the other legalized workers, 293 thousand have moved to other occupations in the U.S. (row d) and 14 thousand have left U.S. employment (row b). Incumbent workers are discouraged from becoming MAW by lower wages. Their employment in MAW falls by 75 thousand (row e). Although 436

thousand MAW workers were legalized, employment of illegal people as MAW falls by only 20 thousand (row f). The departure of legalized and incumbent workers from MAW opens vacancies for new illegal workers. In 2025 there are 416 thousand new illegal people working as MAW (= 436-20). The net change in MAW employment is 34 thousand (row g).

Employment in non-MAW occupations increases by 360 thousand (row m). This is made up of: the 293 thousand legalized workers who come from MAW (row h); 104 thousand extra incumbent workers (row i); and 37 thousand less illegal workers (row l). The increase in incumbent employment in non-MAW occupations is calculated in rows j and k as the 75 thousand incumbents who leave MAW plus a reduction in incumbent unemployment of 29 thousand. Incumbent unemployment is reduced by the shift in the mix of incumbent employment towards higher skilled lower unemployment occupations (factor F4 in the determination of incumbent welfare). Illegal non-MAW employment falls because illegal workers are discouraged by lower wages and reduced vacancies in non-MAW occupations caused by the inflow of legalized and incumbent workers leaving MAW.

With increases of 34 thousand and 360 thousand in MAW and non-MAW employment, the total increase in employment is 394 thousand (row n). This is made up of 29 thousand incumbents coming out of unemployment and 365 (= a+f+l-b) thousand extra non incumbents. The extra non incumbents are mainly low-skilled, low-wage workers, which explains the discrepancy in figure 9 between the people and wagebill measures of unemployment.

Other macro results

Because the employment results in figure 9 for the legalization program are close to a scaled up version of those in figure 1 for the guest-worker program, the results for other macro variables in figures 9 to 11 for the legalization program are broadly a scaled up version of those in figures 1 to 3 for the guest-worker program.

Employment and wages in the agricultural sector

Figures 12 and 13 show the deviation paths for MAW employment and wages caused by the legalization program. In qualitative terms the long-run results in these two figures are similar to those for the guest-worker program (figures 4 and 5). In both sets of figures, the 2025 deviations in incumbent and illegal employment are negative. Although non-incumbent employment includes illegal employment, both sets of figures show strong positive deviations in 2025 in non-incumbent employment. Both sets of figures show: a small increase in total MAW employment; reductions in the wage for a typical hour of both incumbent and non-incumbent labor; and a reduction in the average wage rate of MAW labor (wagebill weights). Just as figure 5 showed an increase in the wage rate for guest workers relative to the baseline wage rate for illegal workers, figure 13 shows an increase in the wage rate for legalized workers relative to the baseline wage rate for illegal workers.

While the argument given earlier in this section makes it clear why legalization leads to an increase in non-incumbent employment of MAW workers and a decrease in incumbent employment, it doesn't explain why figure 12 shows the deviation in non-incumbent employment increasing up to 2018 and then declining. The easiest way to understand this point is to look at the behaviour of incumbent MAW employment. With the productivity increases that occur during the legalization period (up to 2018) there is an "exogenous" increase each year in the effective supply of labor to MAW.

This causes the wage rate for incumbent MAW to fall (figure 13), reducing the supply of incumbent labor to MAW and boosting the employment of non-incumbents.[12] When the legalization program finishes, there are no further "exogenous" supply increases. Legalized workers continue to leave MAW, chasing the higher wages available to them in other occupations. This allows incumbent MAW wages to partially recover (figure 13), bringing back some of the incumbent MAW and thereby reducing non-incumbent MAW employment.

In quantitative terms the long-run effects shown in figures 12 and 13 are generally smaller in absolute terms than the corresponding results in figures 4 and 5. The only exception is the wage rate for the target group, the legalized workers in figure 13 and the guest workers in figure 5. That the MAW wage and employment results are generally smaller in absolute terms for the legalization program than for the guest-worker program may seem surprising when we recall that the legalization program is larger than the guest worker program (436 thousand legalized workers compared with 300 thousand guest workers, see tables 1 and 2). The explanation is that the legalized workers can flow out of MAW whereas the guest workers cannot. The outflow of legalized workers damps the net employment increase of non-incumbent workers under legalization relative to that under the guest worker program. At the same time the outflow under legalization damps the wage reductions for MAW workers relative to the reductions under the guest-worker program, and leaves the target group with a higher wage under legalization than under the guest-worker program.

Other agricultural variables

The legalization results in figure 14 for key agricultural variables are qualitatively similar to the guest-worker results in figure 6. As in the guest-worker program, the

reduction in the average cost of MAW in the legalization program leads to a reduction in the farm-gate prices of agricultural products (0.28 per cent in 2025) with a muted reduction in food prices (0.08 per cent). The reduction in farm-gate prices leads to a long-run expansion of exports of agricultural products (0.52 per cent) and contraction in imports (0.48 per cent). Output of agricultural products increases by 0.38 per cent. Supporting the increase in agricultural output are increases in inputs of capital and labor.

The long-run (2025) effects shown in figure 14 for the legalization program are smaller in absolute size than the corresponding effects shown in figure 6 for the guest-worker program. This is because the long-run reduction in the average cost of MAW is smaller in the legalization program than in the guest-worker program (2.18 per cent compared with 3.67 per cent, figures 13 and 5). The change in the direction in the deviation paths after 2018 is more pronounced in figure 14 than in figure 6, reflecting the shaper recovery beyond 2018 in the average cost of MAW under legalization than under the guest-worker program.

Figure 15 shows the effects of the legalization program on real farm income under the assumption that farmer labor is 100% MAW. The figure confirms the counter-intuitive result that we explained in the context of figure 7: reductions in the costs of labor supplied by MAW can reduce farm income. With the long-run reduction in the average cost of MAW being smaller under legalization than under the guest-worker program, the long-run outcome for farm income is more favourable (a loss of 0.03 per cent in figure 15 compared with 0.23 per cent in figure 7 for the 100% MAW case).

Conclusion

The general equilibrium method adopted in this article has enabled us to identify several effects of agriculture-focused immigration policies that would not have been revealed by partial equilibrium analysis applied to the agricultural sector alone. By considering inter-sectoral labor market flows, we have shown that guest-worker and legalization programs for agriculture are likely to have similar effects on the sector even though the former ties the target group of foreign workers to agriculture while the latter facilitates their flow out of agriculture. By considering the role of vacancies in determining occupational choices, we have shown how the two programs cause a gradual welfare-enhancing transformation of the mix of incumbent employment away from agriculture towards higher wage occupations. By considering macroeconomic relationships, we have shown how the programs affect trade volumes, the terms of trade, investment, capital stock, aggregate incumbent employment and GDP, and how, through these channels the programs affect incumbent welfare. Adoption of the general equilibrium approach has not prevented us from specifying the agricultural sector in our model in considerable detail. By considering the nature of farmer-supplied labor, we have identified the possibility that reductions in the unit cost of hired labor could reduce farm income.

To conclude the article, we apply the general equilibrium approach to one more question: how would further tightening of border security to restrict the inflow of illegal immigrants affect agriculture? Given agriculture's heavy reliance on illegal workers, there is a fear that cutting their inflow will disproportionately damage the sector, with deteriorations in farm output, farm income and food security. For this reason, immigration reform proposals generally contain special policies for agriculture of the type analysed in this article.

Column (1) of table 3 contains results from a border- security-tightening simulation. The results in columns (2) and (3) are from the central guest-worker simulation (farmer effort is 100% MAW) and the legalization simulation (also with farmer effort being 100% MAW). The results in column (4) are from a simulation in which we apply both the guest-worker and legalization programs. The column (4) results are close to an addition of the results in columns (2) and (3). Column (5) gives results for a combined border security, guest worker, legalization program. The results in this column are close to an addition of those in columns (1), (2) and (3).

Results from border-security simulations similar to that in column (1) of table 3 are explained in our earlier articles (see Dixon and Rimmer, 2010; Dixon, Johnson and Rimmer, 2011; Dixon, Rimmer and Roberts, 2014; and Zahnizer *et al.* 2012). Here we give only a brief explanation. The border-security policy is introduced to USAGE as shocks to variables specifying the preferences of potential illegal immigrants for employment in the U.S. versus employment in their home countries. We do not specify the exact nature of the policy, only that it: is implemented in 2015-16; is maintained through our simulation period to 2025; and sufficiently discourages illegal entry that by 2025 illegal employment is 29.47 per cent (or about 2 million people) below its baseline level [row 5, column (1), table 3].

The cut in illegal employment reduces GDP by 1.32 per cent [row 1, column (1)]. This reflects not only a reduction in labor input but a complementary reduction in capital input. Incumbent welfare falls by 0.79 per cent [row 2, column (1)]. This is explained by the net outcome of the six factors discussed in relation to figures 3 and 11. Generally, these have opposite signs from those applying for the guest-worker and legalization programs. Cutting employment in the U.S. of low-skilled illegal workers

through tighter border security: increases the cost to the U.S. of employing the remaining illegal workers (a negative value for F1); deteriorates the occupational mix of incumbent employment (negative F2); reduces the U.S. capital stock (negative F3); increases the overall unemployment rate for incumbents (negative F4); reduces public expenditures devoted to illegal residents (positive F5); and improves the terms of trade (positive F6).

Despite the heavy reliance of the agricultural sector on illegal labor, the percentage reduction in agricultural output in column (1) of table 3 is smaller than that in GDP (1.27 compared with 1.32). Tighter border security increases the cost of labor to agriculture: the average cost of MAW in column (1) rises by 2.68 per cent (row 11). However, the effect on agricultural output is damped by two factors. First, the elasticity of demand for most agricultural products is quite low, and second, agricultural output is stabilized by the presence in the sector of fixed factors. The most obvious of these is agricultural land. But we also treat farmer labor as a fixed factor. Together these two fixed factors account for about 40 per cent of total value added in the agricultural sector. To a large extent, an increase in the cost of hired labor is absorbed by reductions in returns to these fixed factors.

Reductions in returns to fixed factors keep U.S. agriculture internationally competitive in the tighter border security simulation despite the increase in the cost of MAW. Thus we see almost no change in agricultural exports [-0.12 per cent, row 8, column (1)] and a decline in Agricultural imports (1.24 per cent, row 9) in line with the decline in the overall size in the U.S. economy. As measured by the balance of trade in agricultural products, food security is improved by tighter border security.

Rows 10 and 11 of column (1) in table 3 show that an increase in MAW costs arising from tighter border security causes a reduction in real farm income (1.48 per cent, row 10). Unlike the results in the central simulations for the guest-worker and legalization programs [reproduced in table 3], the border-security simulation gives movements for MAW costs and real farm income that have opposite sign. The explaining difference is population effects. The guest-worker and legalization programs cause only small changes in the number of people residing in the U.S. (a few hundred thousand in each case). By contrast, the tighter border security program causes a much more significant change, a decrease of about 2 million. With less people there is a reduction in the demand for food. This reduces the rental value of agricultural land in the tighter security simulation sufficiently to outweigh the positive effect on farm income of the increase in the value of farmer-supplied labor. In terms of figure 8, it is legitimate to assume that the demand curve is fixed in an analysis of an agriculture-focused guest-worker or legalization program. But this assumption is not appropriate for a larger-scale tighter-border-security program.

So what does table 3 tell us about: (a) damage to agriculture from a policy of tighter border security and (b) the mitigating effects of special agricultural policies such as guest-worker and legalization programs? In terms of the fears mentioned earlier in this section, the results table 3 indicate that tighter border security would not cause problems with either agricultural output or food security. Inelastic supply from agriculture means that there would not be a disproportionate reduction in agricultural output. With a relatively small reduction in agricultural output and a significant reduction in population, food security is likely to improve: a reduction in imports and little change in exports. However, farm income would be adversely affected by tighter

border security. Taking account of the results in row 10 of table 3 and the sensitivity results shown in figure 7, it is clear that guest-worker and legalization programs of the size and type studied here may exacerbate (and certainly not overcome) the negative effects on farm income of a successful tighter-border-security program of significant magnitude.

References

Armington, P.S. (1969), "The geographic pattern of trade and the effects of price changes", *IMF Staff Papers*, XVI, pp. 176-199.

Bipartisan Policy Center (2013), *Immigration reform: Implications for growth, budgets and housing*, Washington DC, October, pp. 35, available at http://bipartisanpolicy.org/events/immigration-reform-implications-growth-budgets-and-housing/

Borjas, G.J. (1994), "The economics of immigration", *Journal of Economic Literature*, XXXII, December, pp. 1667-1717.

Borjas, G.J. (1999), "The economic analysis of immigration", in *Handbook of Labor Economics*, 3a, edited by Orley C. Ashenfelter and David Card. *Handbook of Economics 5*, Elsevier, pp. 1697-1760.

Borjas, G.J. (2003), "The labor demand curve *is* downward sloping: re-examining the impact of immigration on the labor market", *The Quarterly Journal of Economics*, November, pp. 1335-74.

Borjas, G.J., J. Grogger, and G.H. Hanson (2008), "Imperfect substitution between immigrants and natives: a reappraisal", NBER working paper 13887, Cambridge, MA, March, pp. 40, http://www.nber.org/papers/w13887 .

Borjas, G.J., J. Grogger and G.H. Hanson (2010), "Immigration and the economic status of African-American men", *Economica*, vol. 77, pp. 255-82.

Card D. (2005), "Is the new immigration really so bad?", *Economic Journal*, 115(507), November, pp. F300-F323.

Dixon, P.B. and M.T. Rimmer (2010), "U.S. imports of low-skilled labor: restrict or liberalize?", chapter 5, pp. 103-51 in John Gilbert (editor) *New Developments in Computable General Equilibrium Analysis of Trade Policy*, Volume 7 of H. Beladi and K. Choi (series editors) *Frontiers of Economics and Globalization*, Emerald Publishing, UK.

Dixon, P.B., M. Johnson and M.T. Rimmer (2011), "Economy-wide effects of reducing illegal immigrants in U.S. employment" *Contemporary Economic Policy*, Vol. 29(1), January, pp. 14-30.

Dixon, P.B., R.B. Koopman and M.T. Rimmer (2013), "The MONASH style of CGE modeling: a framework for practical policy analysis", Chapter 2, pp. 23-102 in P.B. Dixon and D.W. Jorgenson (editors) *Handbook of Computable General Equilibrium Modeling*, Elsevier.

Dixon, P.B. M.T. Rimmer and B.W. Roberts (2014), "Restricting employment of low-paid immigrants: a general equilibrium assessment of the social welfare implications for legal U.S. wage-earners" C*ontemporary Economic Policy*, vol. 32(3), pp. 639-52.

Espenshade, T. (1994), "Does the threat of border apprehension deter U.S. immigration?", *Population and Development Review*, 20(4), pp. 871-892.

Hanson, G.H. and A. Spilimbergo (1999), "Illegal immigration, border enforcement and relative wages: evidence from apprehensions at the US-Mexico border", *American Economic Review*, 89(5), pp. 1337-1357.

Hanson, G.H. and A. Spilimbergo (2001), "Political economy, sectoral shocks and border enforcement", *Canadian Journal of Economics*, 34(3), pp. 612-638.

Hoppe, R., J. MacDonald, and P. Korb (2010), "Small Farms in the United States: Persistence Under Pressure," *Economic Information Bulletin No. EIB-63*, February, available at: www.ers.usda.gov/publications/eib-economic-information-bulletin/eib63.aspx

Kossoudji, S (1992), "Playing cat and mouse at the Mexican-American border", *Demography*, 29(2), pp. 159-180.

Ottaviano G.I.P, and G. Peri (2006), " Rethinking the effects of immigration on wages", NBER Working Paper Series, National Bureau of Economic Research, Cambridge, MA, August, pp. 44.

Rector, R. and C. Kim (2007), "The Fiscal Cost of Low-Skill Immigrants to the U.S. *Taxpayer", Heritage Special Report SR-14, Heritage Foundation, Washington, DC*, May, pp. 70, http://www.heritage.org/Research/Immigration/sr14.cfm .

Reyes, B. (2004), "Changes in trip duration for Mexican immigrants to the United States", *Population Research and Policy Review*, 23(3), pp. 235-257.

Strayhorn, C.K. (2006), "Undocumented immigrants in Texas: a financial analysis of the impact to the state budget and economy", *Special Report*, Office of the Comptroller of Texas, December, pp. 22.

Treyz, F.R., C. Stottlemyer and R. Motamedi (2013), "Key components of immigration reform", Regional Economic Models Inc, July, pp. 29, available at

http://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=2&ved=0CCQQFjABahUKEwimwY7D_pfJAhUK7SYKHa0ZB8U&url=http%3A%2F%2Fwww.remi.com%2Fdownload%2FKey%2520Components%2520of%2520Immigration%2520Reform.pdf&usg=AFQjCNEaVeTnfq2HpYE8Ze7B7Kt5c3nKsQ .

Zahniser, S., T. Hertz, P.B. Dixon and M. Rimmer (2012), "Immigration policy and its possible effects on U.S. agriculture and the market for hired farm labor: a simulation analysis", *American Journal of Agricultural Economics*, vol. 94(2), January, pp. 477-82.

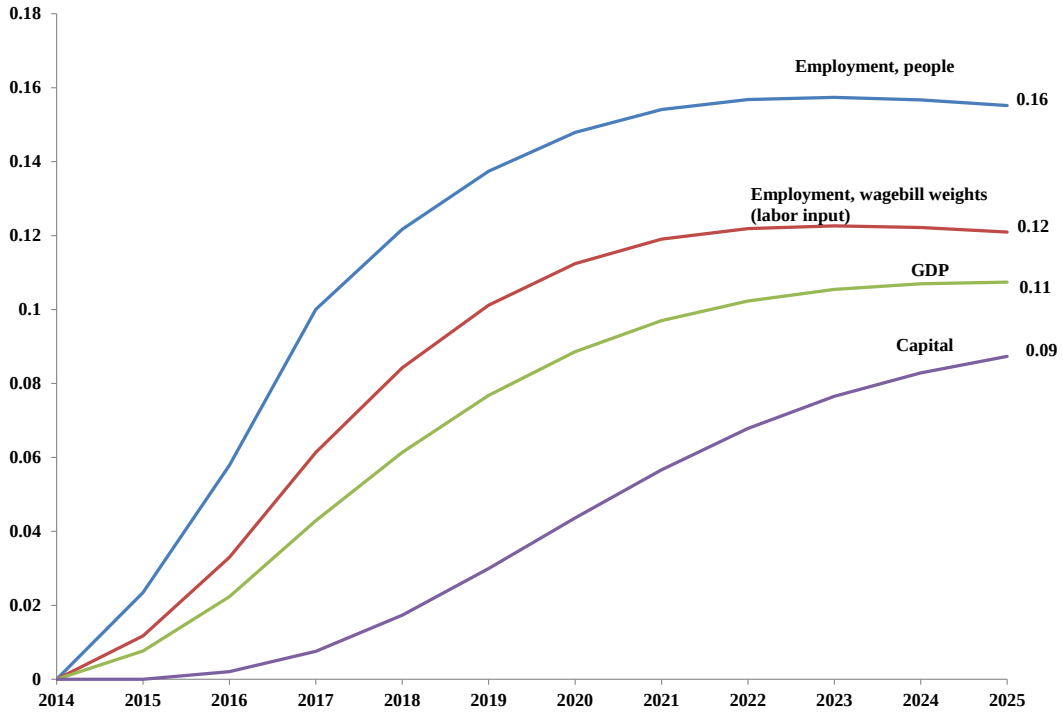


Figure 1. Guest-worker program for Agriculture: GDP; capital; employment wagebill weights; and employment persons (*percentage deviations from baseline*)

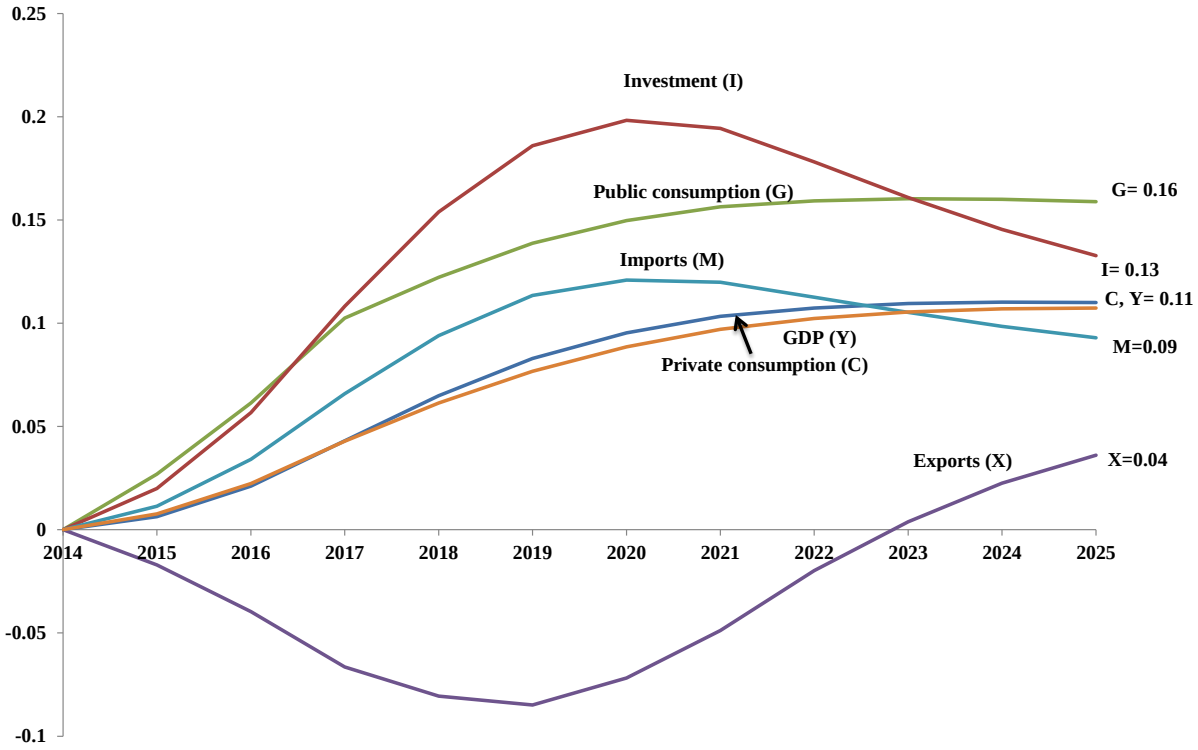


Figure 2. Guest-worker program for Agriculture: effects on real expenditure aggregates (*percentage deviations from baseline*)

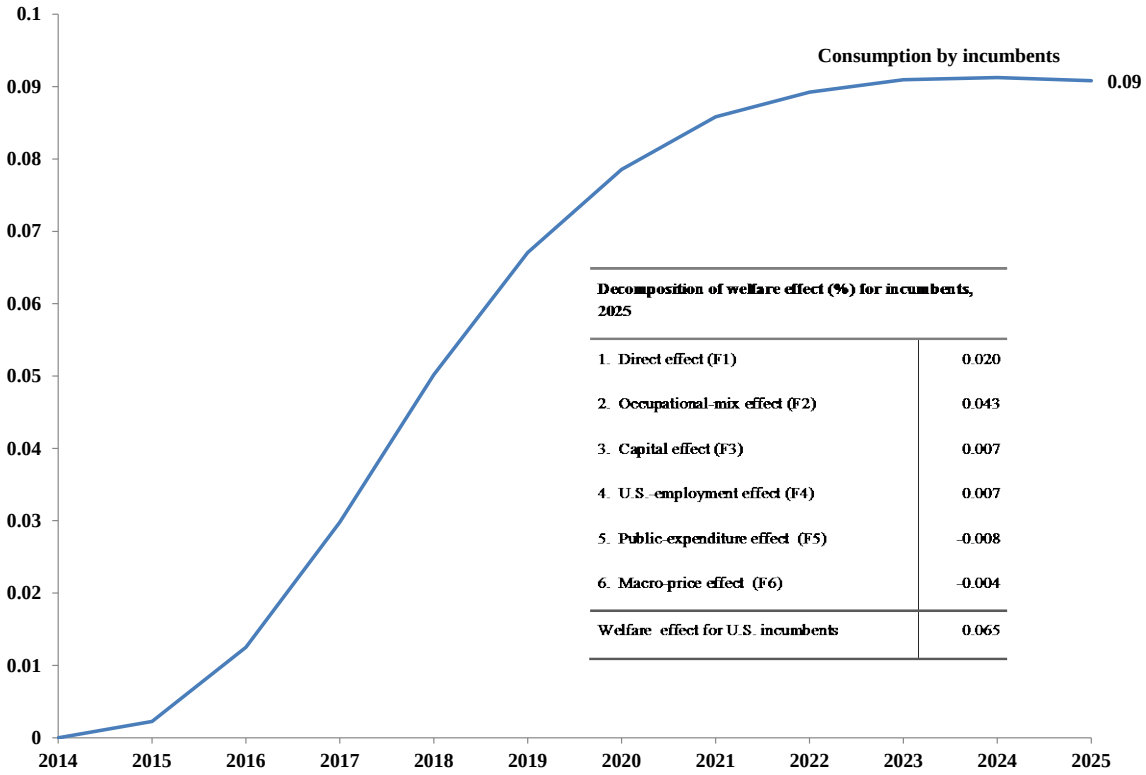


Figure 3. Guest-worker program for Agriculture: effects on consumption and welfare of incumbents (*percentage deviations from baseline*)

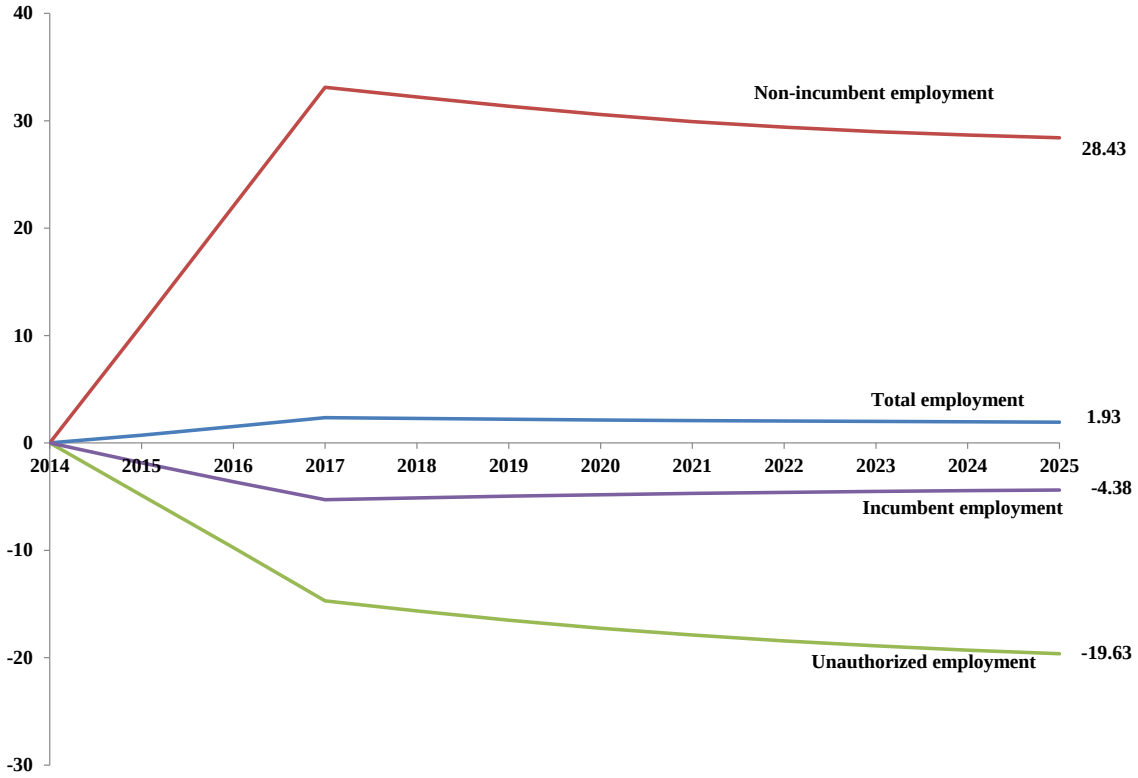


Figure 4. Guest-worker program for Agriculture: effects on employment (people measure) of Miscellaneous agricultural workers (*percentage deviations from baseline*)

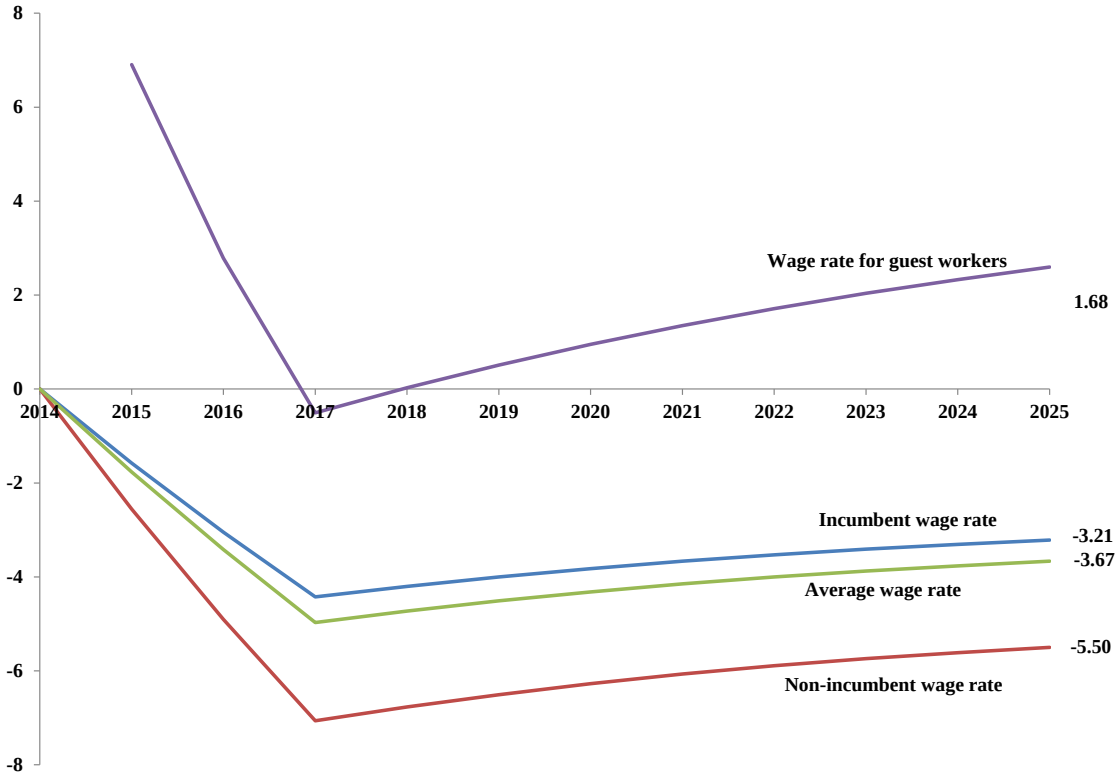


Figure 5. Guest-worker program for Agriculture: effects on real wage rates of Miscellaneous agricultural workers (*percentage deviations from baseline*)

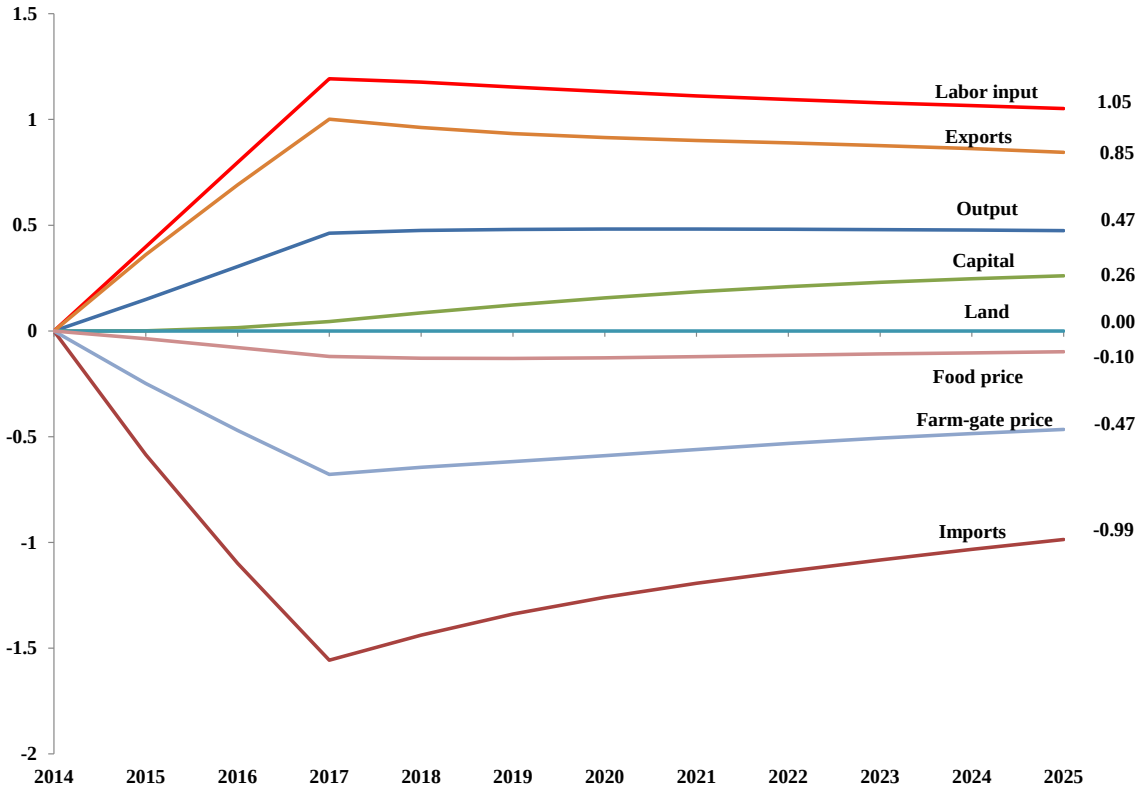


Figure 6. Guest-worker program for Agriculture: effects on inputs, output, prices, exports & imports in the agricultural sector (percentage deviations from baseline)

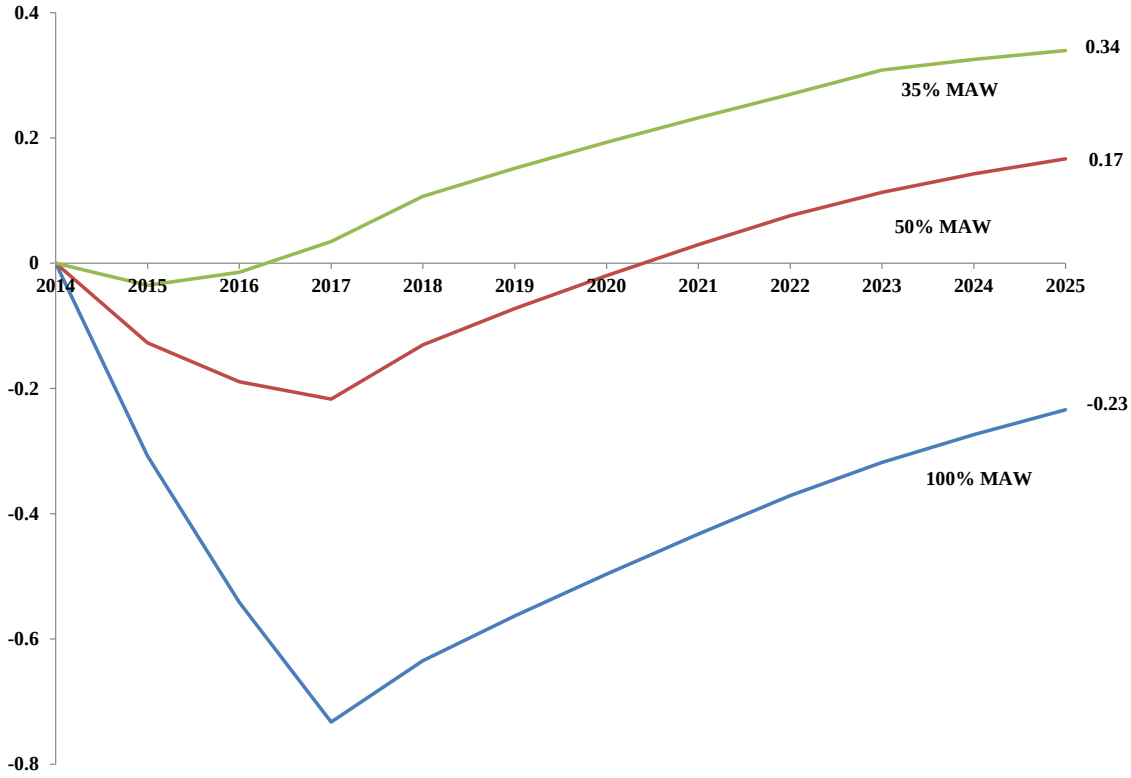


Figure 7. Guest-worker program for Agriculture: effects on real farm income under different assumptions for the MAW fraction of farmer-supplied labor (*percentage deviations from baseline*)

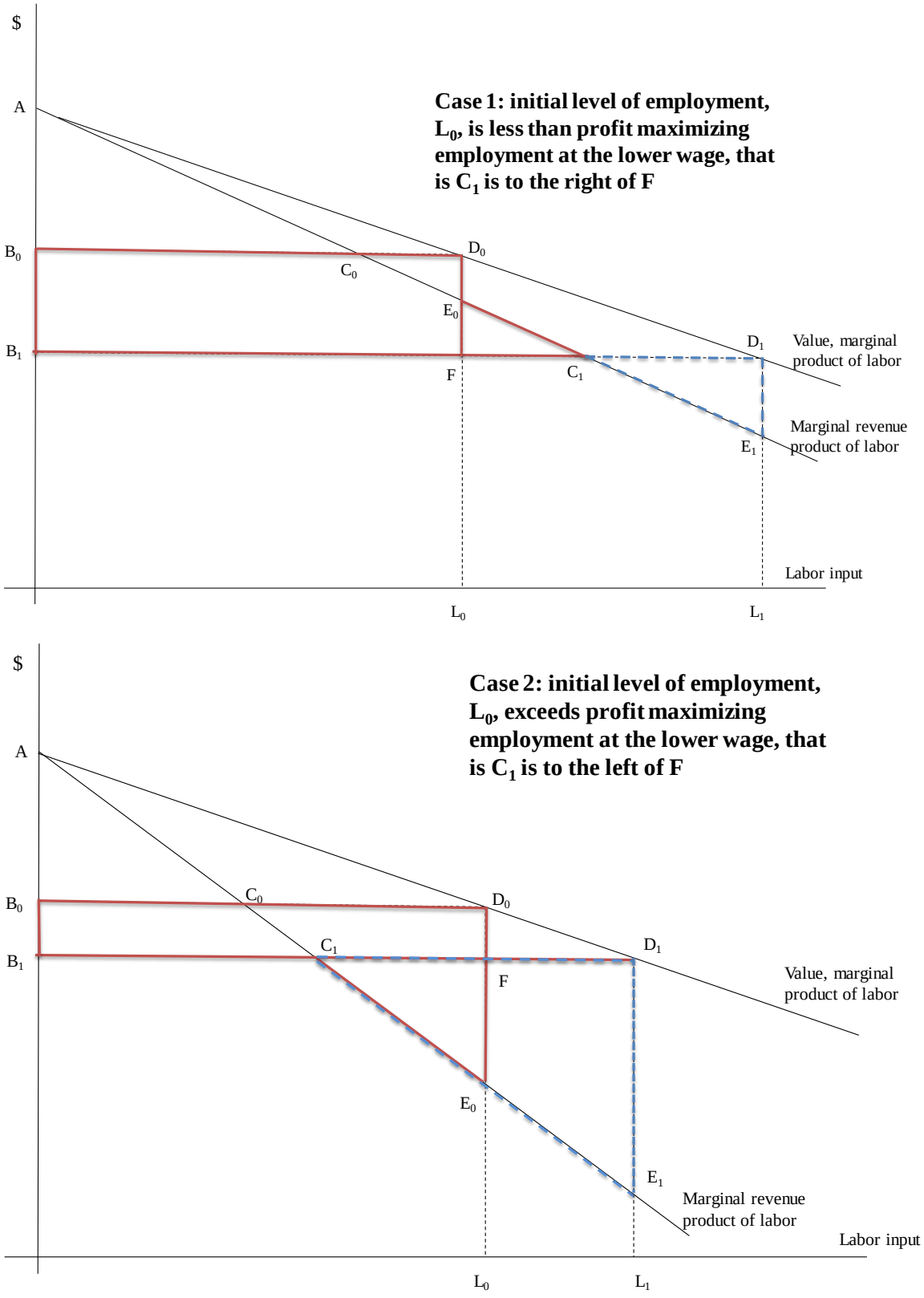


Figure 8. Employment, farm profits and farm income in a stylized model

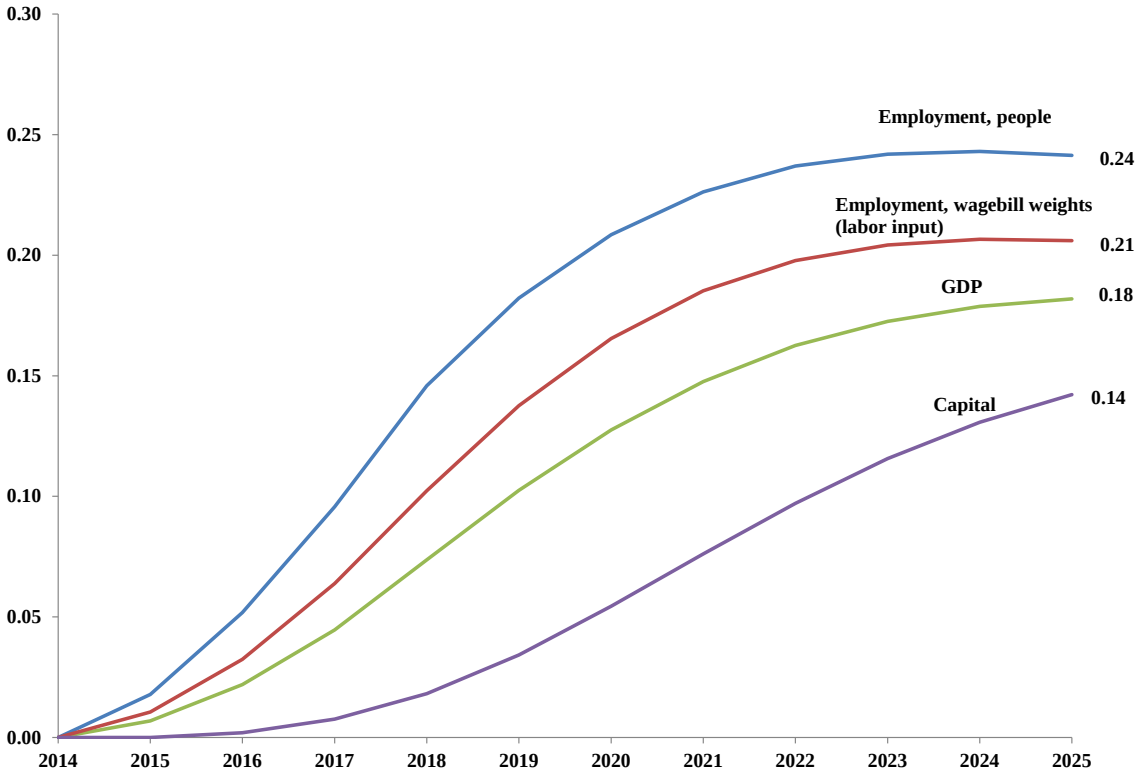


Figure 9. Legalization program for Agriculture: GDP; capital; employment wagebill weights; and employment persons (*percentage deviations from baseline*)

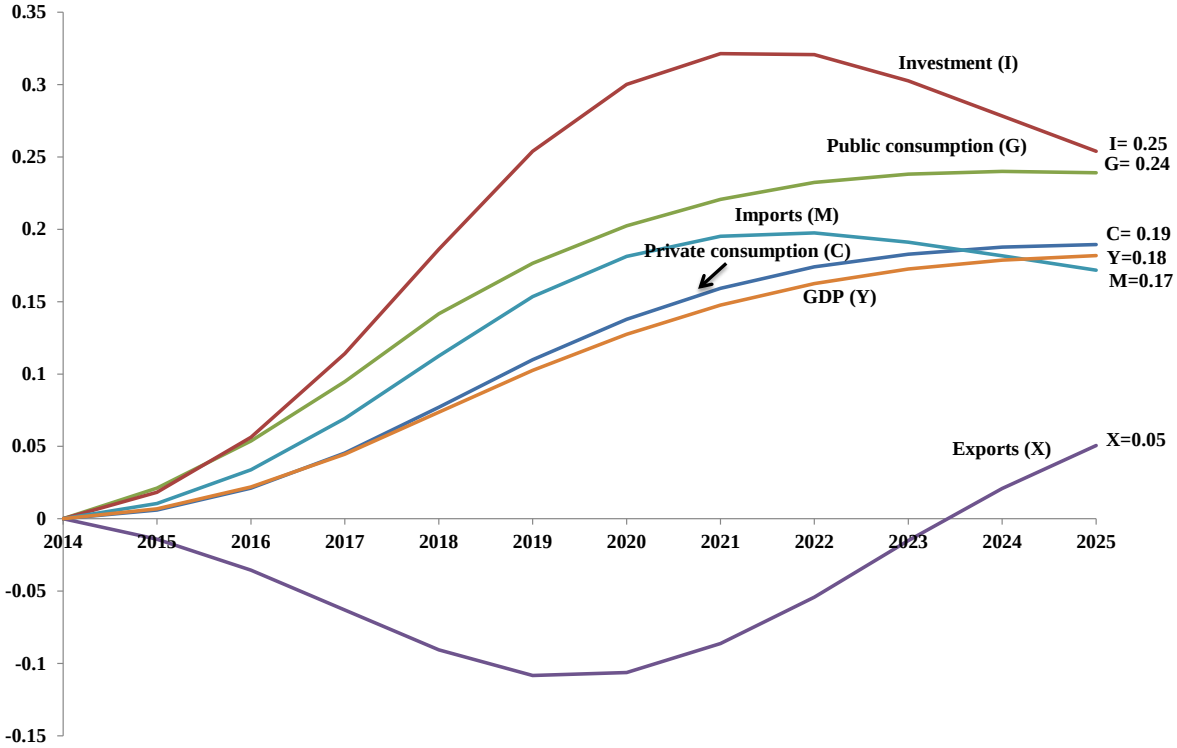
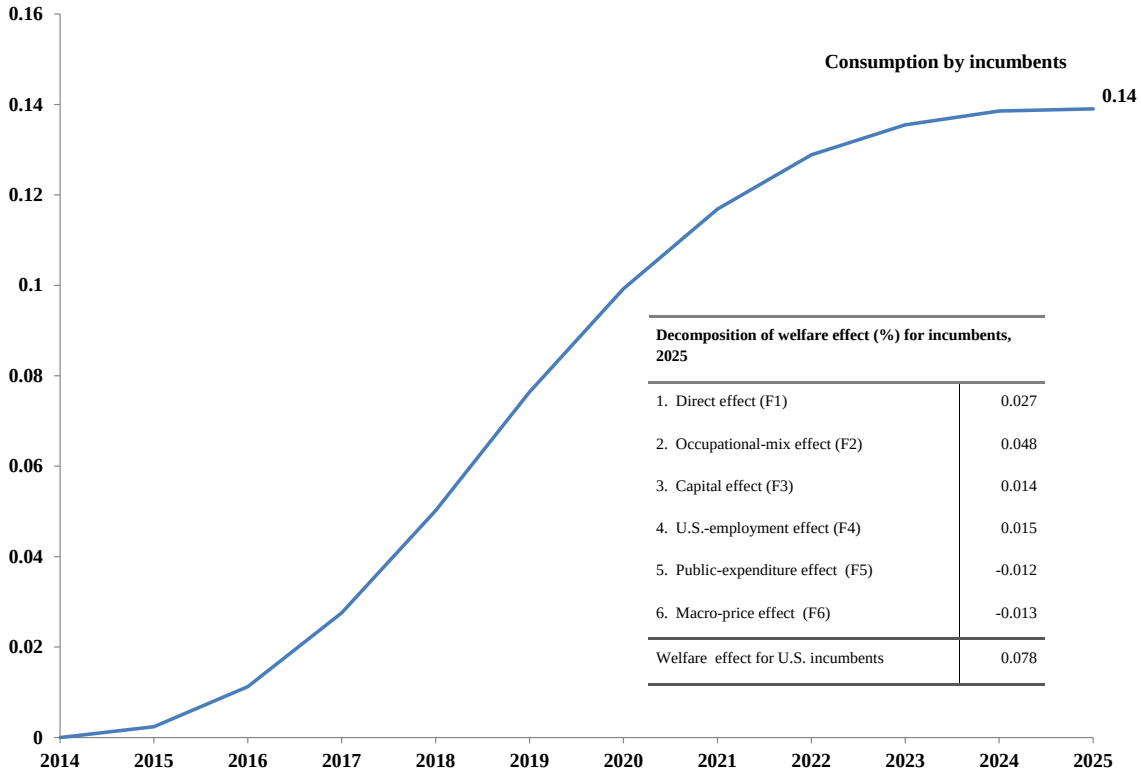


Figure 10. Legalization for illegal agricultural workers: effects on real expenditure aggregates (*percentage deviations from baseline*)



Decomposition of welfare effect (%) for incumbents, 2025	
1. Direct effect (F1)	0.027
2. Occupational-mix effect (F2)	0.048
3. Capital effect (F3)	0.014
4. U.S.-employment effect (F4)	0.015
5. Public-expenditure effect (F5)	-0.012
6. Macro-price effect (F6)	-0.013
Welfare effect for U.S. incumbents	0.078

Figure 11. Legalization for illegal agricultural workers: effects on consumption and welfare of incumbents (percentage deviations from baseline)

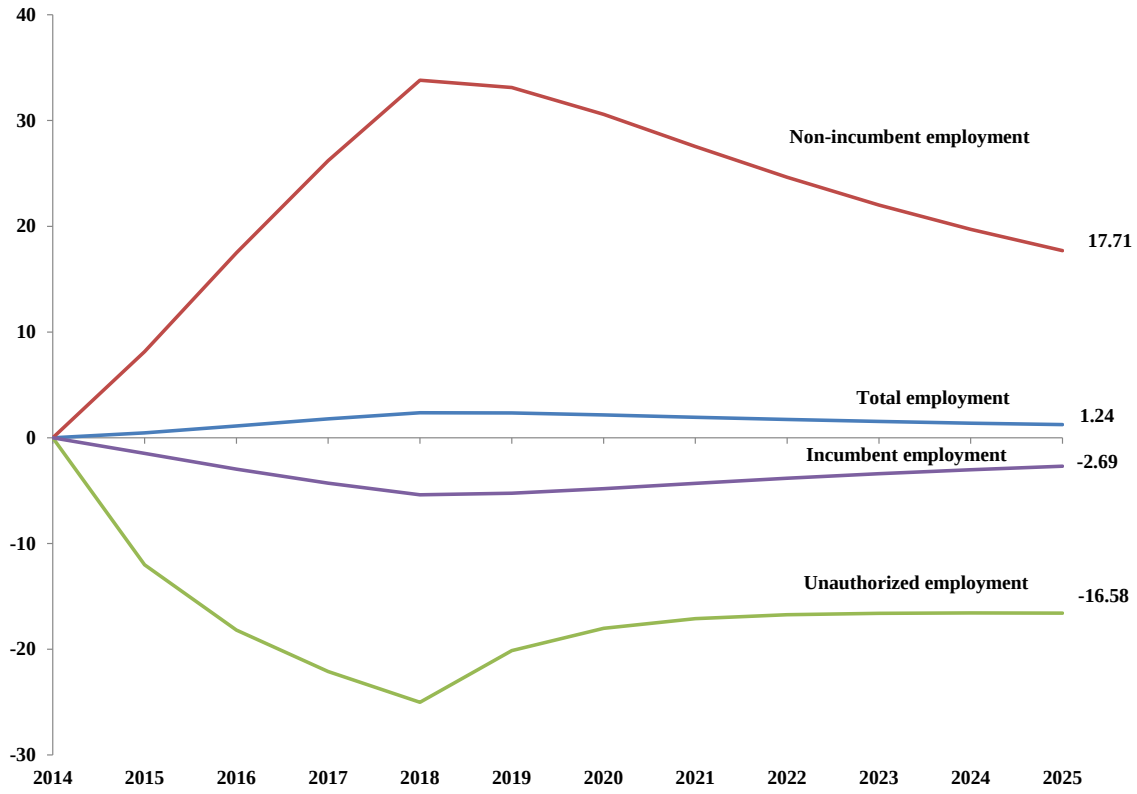


Figure 12. Legalization for illegal agricultural workers: effects on employment (people measure) of Miscellaneous agricultural workers (*percentage deviations from baseline*)

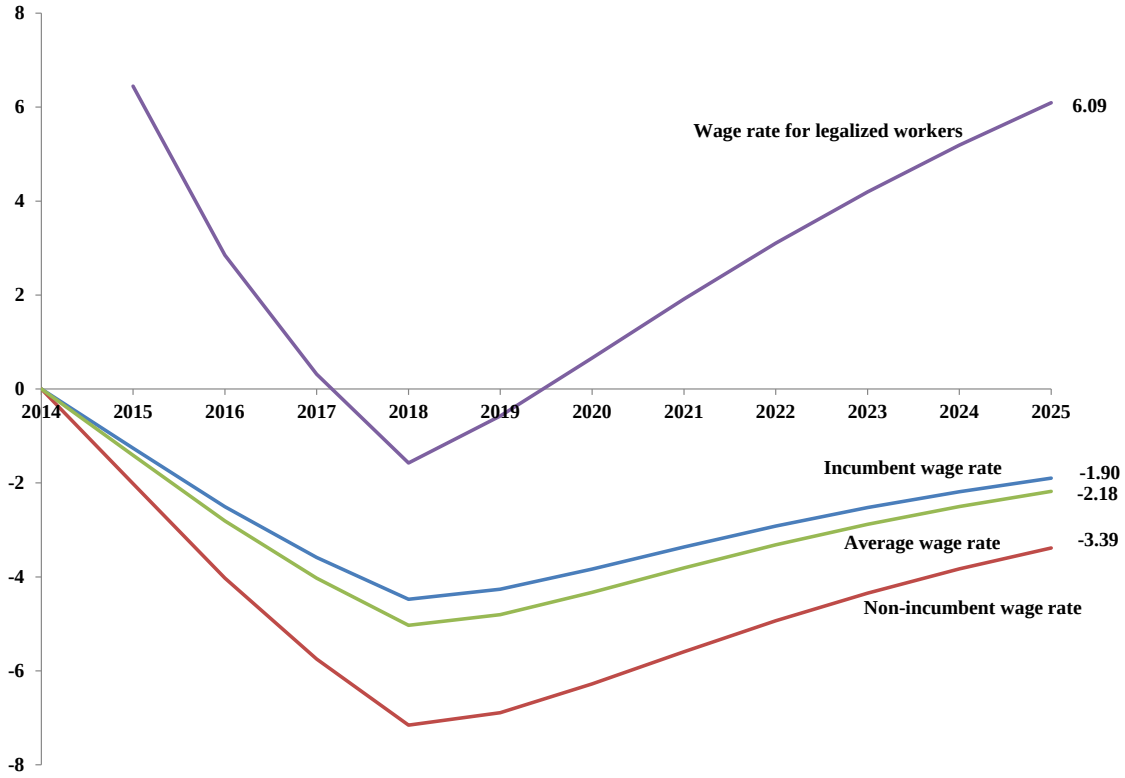


Figure 13. Legalization for illegal agricultural workers: effects on real wage rates of Miscellaneous agricultural workers (*percentage deviations from baseline*)

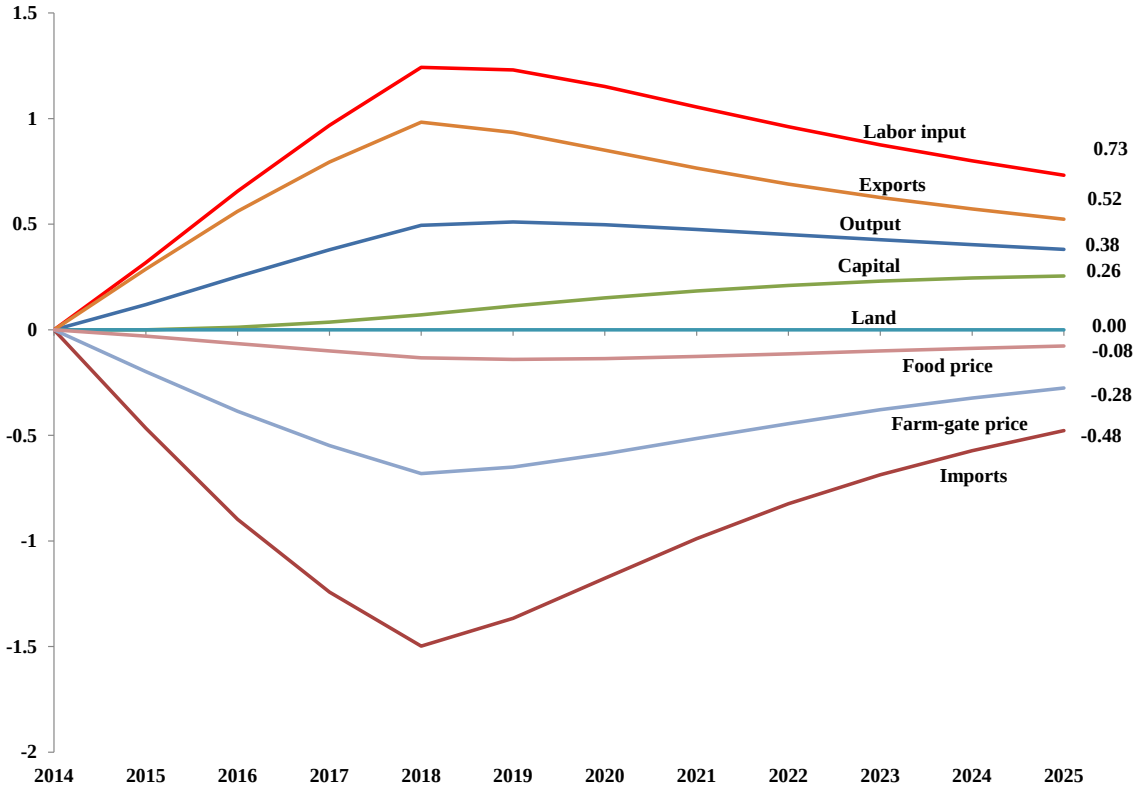


Figure 14. Legalization for illegal agricultural workers: effects on inputs, output, prices, exports & imports in the agricultural sector (*percentage deviations from baseline*)

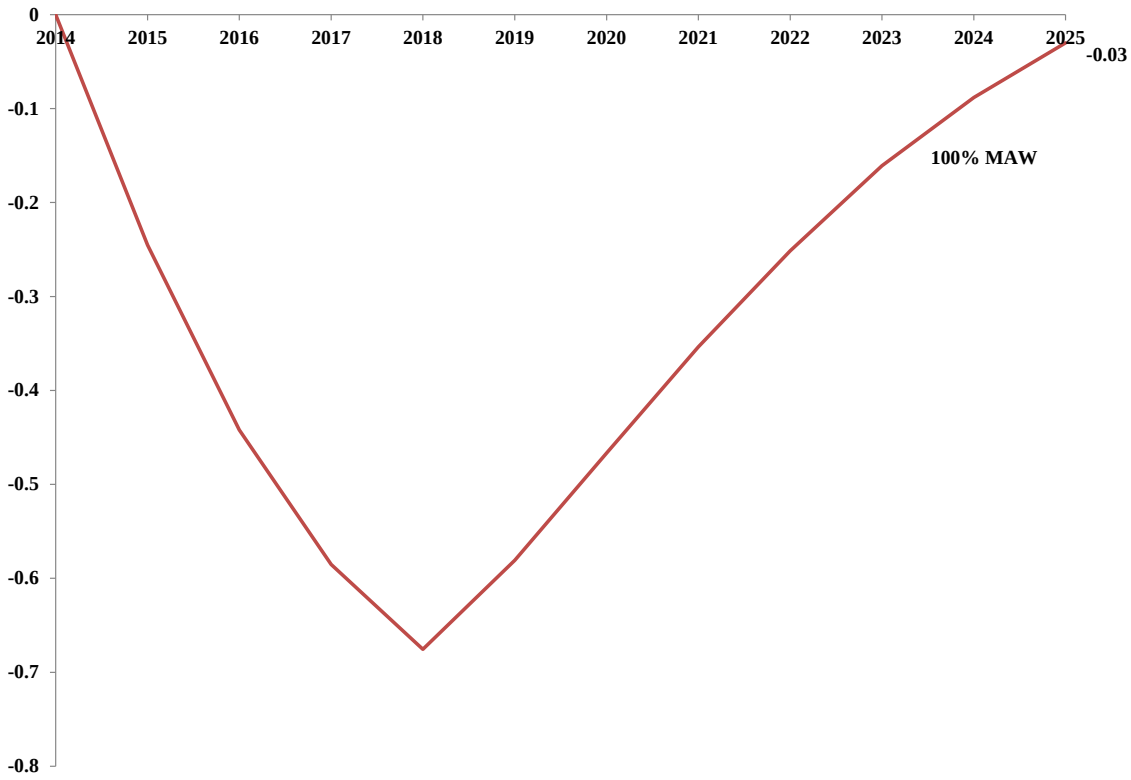


Figure 15. Legalization for illegal agricultural workers: effects on real farm income (*percentage deviations from baseline*)

Table 1. Guest-worker program: employment (people) effects in 2025

Row			Persons in thousands
		MAW (Miscellaneous agric. workers)	
a	(= b+c+d)	No. of MAW guest workers by 2025	300
b		No. who leave U.S. employment (net)	0
c		No. still in MAW	300
d		No. in other occupations	0
e		Change in incumbent MAW	-115
f		Change in illegal MAW	-123
g	(= c+e+f)	Net change in MAW employment	62
		Other occupations	
h		Inflow of MAW guest workers	0
i	(= j+k)	Inflow of incumbents	131
j		Reduction in incumbent MAW	115
k		Reduction in incumbent unemployment	15
l		Inflow of illegal	63
m	(= h+i+l)	Increase in Non-MAW employment	193
		Total employment	
n	(= g+m)	Total increase in employment	255
o		Percentage increase in employment	0.16%

Table 2. Legalization program: employment (people) effects in 2025

Row		Persons in thousands
	MAW (Miscellaneous agric. workers)	
a (= b+c+d)	No. of MAW transitioned to legal by 2025	436
b	No. who leave U.S. employment	14
c	No. still in MAW	129
d	No. in other occupations	293
e	Change in incumbent MAW	-75
f	Change in illegal MAW	-20
g (= c+e+f)	Net change in MAW employment	34
	Other occupations	
h	Inflow of legalized workers	293
i	Inflow of incumbents	104
j	Reduction in incumbent MAW	75
k	Reduction in incumbent unemployment	29
l	Inflow of illegal	-37
m (= h+i+l)	Increase in Non-MAW employment	360
	Total employment	
n (= g+m)	Total increase in employment	394
o	Percentage increase in employment	0.24%

Table 3. Tighter border security compared with guest-worker and legalization programs for MAW (*percentage deviation from baseline in 2025*)

	Variable	Tighter border security	Guest-worker program	Legalization program	Full agricultural program: Guest-worker & Legalization	Full agricultural program with tighter border security
		(1)	(2)	(3)	(4) ≈ (2)+(3)	(5) ≈ (1)+(4)
1	Real GDP	-1.32	0.11	0.18	0.27	-1.06
2	Incumbent welfare	-0.79	0.09	0.14	0.22	-0.58
3	Non-incumbent employment	-29.47	2.55	3.82	6.08	-23.22
4	Incumbent employment	-0.15	0.01	0.02	0.03	-0.13
5	Illegal employment	-29.47	-0.75	-0.71	-1. 46	-30.93

(continued)

Table 3 Continued.

	Variable	Tighter border security	Guest-worker program	Legalization program	Full agricultural program: Guest-worker & Legalization	Full agricultural program with tighter border security
		(1)	(2)	(3)	(4) ≈ (2)+(3)	(5) ≈ (1)+(4)
6	Agricultural output	-1.27	0.47	0.38	0.83	-0.36
7	Agricultural employment, wagebill weights	-1.84	1.05	0.73	1.77	0.09
8	Agricultural exports	-0.12	0.85	0.52	1.35	1.40
9	Agricultural imports	-1.24	-0.99	-0.48	-1.43	-2.91
10	Real farm income	-1.48	-0.23	-0.03	-0.29	-1.84
11	Average wage for MAW	2.68	-3.67	-2.18	-5.71	-3.91

[1] In our database for 2013, the share of illegal workers in labor costs for the agricultural sector is 15 per cent, with much higher shares in Fruits, Treenuts and Vegetables (between 25 and 40 per cent). The sector with the next highest share is Construction (10 per cent). For the economy as a whole the share is about 3 per cent.

[2] By incumbents we mean residents excluding guest, legalized and illegal workers and their families.

[3] Quantity of labor measured in hours required to perform a standard task.

[4] The cells illegal, domestic are empty. There are no illegal, domestic workers.

[5] If demand for their original activity is very low then it is possible that some of these people move to unemployment.

[6] This is occupation 45-2090 in statistics published by the U.S. Bureau of Labor Statistics.

[7] For example, assume that $Y = K^{\alpha} * L^{\beta}$ where $\alpha + \beta < 1$. The marginal product of capital is $\alpha * K^{\alpha-1} * L^{\beta}$ which is constant in the long run. Thus, in percentage change terms: $(\alpha - 1) * k + \beta * \ell = 0$ where lower case symbols represent percentage changes or log changes in the corresponding uppercase variables. Rearranging gives $k = [\beta/(1-\alpha)] * \ell$. The coefficient $\beta/(1-\alpha)$ is positive but less than 1. Consequently an increase in labor input (e.g. a guest-worker program) causes a long-run decrease in K/L.

[8] The wagebill weighted average gives the best indication of what the guest-worker program does to the cost to farmers of obtaining sufficient labor to perform a given task, e.g. picking a ton of tomatoes. The wagebill measure reflects productivity differences across categories of workers (guest-worker versus illegal versus incumbent).

[9] The Economic Research Service (ERS) in the U.S. Department of Agriculture (Hoppe, MacDonald and Korb, 2010) defines net farm income as gross cash receipts – cash expenses – depreciation + minor items (home consumption + imputed value of farm dwelling + net inventory change - noncash benefits for paid labor). Recognizing that gross receipts – cash expenses is the returns to farm factors (land, capital and farmer labor), we can reconfigure the ERS definition as:

net farm income + depreciation = farm income = returns to farm factors + minor items.

Thus, apart from minor items our definition of farm income corresponds to the ERS definition.

[10] For simplicity in this stylized model we ignore intermediate inputs and production taxes/subsidies.

[11] This definition is a little broader than the ERS concept of operating profit (Hoppe, MacDonald and Korb, 2010). Operating profit under the ERS definition is net farm income – return to farmer labor (both MAW and management) + interest. That is,

Operating profit = farm income – return to farmer labor +(interest –depreciation)

which is approximately returns to land and capital. Our definition of farm profits is returns to land, capital and farmer-supplied management services, that is returns to fixed factors.

[12] Illegal employment falls. But this masks an inflow of new illegal workers. The fall in illegal employment is less than would be expected on the basis of the number of illegal workers that are transitioned to legalized status.