Unemployment, Growth and Welfare Effects of Labor Market Reforms

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Abstract

The effects of labor market reforms are studied in an innovation-driven model of endogenous growth with a heterogeneous labor force, labor market rigidities, and structural unemployment. The model is calibrated for "typical" high- and middle-income economies and used to perform a range of experiments, including both individual labor market reforms (cuts in the minimum wage and unemployment benefit rates) and composite reform programs involving additional measures. The results show that individual reforms may generate conflicting effects on growth and welfare in the long run, even in the presence of positive policy externalities. A reduction in training costs may also create an oversupply of qualified labor and higher unemployment in the long-run. The effectiveness of labor market reforms, in terms of promoting growth and employment, is enhanced when they are accompanied by productivity-enhancing policies. Public investment in infrastructure, partly through its effects on innovation, may help to mitigate the trade-off between growth and welfare associated with these reforms.

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1 Introduction

The impact of labor market reforms on unemployment and economic growth has been the focus of a large theoretical and empirical literature. From an analytical perspective, important issues in that context are the modeling of the production structure and the causes of mismatches between supply and demand in the labor market. Accounting for innovation activities for instance is critical to study the role of human capital accumulation, knowledge externalities, and the distribution of skills as sources of growth and employment; and modeling labor market rigidities (both economic and institutional) is essential to explain unemployment. These rigidities have taken the form of government legislation on minimum wages, mandated firing costs, unemployment benefits, payroll taxes (Daveri and Tabellini (2000)), collective bargaining (Varga et al. (2014), Bhattacharyya and Gupta (2015) and Chang and Hung (2016)), search and matching frictions in the Mortensen-Pissarides tradition (Zagler (2009) and Cacciatore and Fiori (2016)), and efficiency wages (van Schaik and de Groot (2000), Meckl (2001, 2004), Bucci et al. (2003), Parello (2011), and Zagler (2011)).[1] A key result from the literature is that the relationship between growth and unemployment may be weak, both in the short run and in the long run.

However, the existing literature suffers from four major shortcomings. First, except for a few contributions—such as Cacciatore and Fiori (2016), albeit in a business cycle setting—most of the literature neglects transitional dynamics. As a result, the dynamic trade-offs that may be associated with labor market reforms, that is, the possibility of conflicting effects in the short and the longer run in terms of their impact on either unemployment or growth specifically, cannot be ascertained. Second, almost none of the existing models considers the supply side of the labor market. In particular, the distribution of the labor force across levels of education, and how it changes over time, are seldom explicitly analyzed.[2] This creates a major difficulty in terms of understanding how the labor market adjusts in response to shocks, how it interacts with the process of

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[1] Some of these contributions also account for the existence of an innovation sector, albeit (as discussed next) in a partial manner.

[2] Some models introduce a work-leisure trade-off into workers' utility functions (thereby accounting for the intensive margin of labor supply), but the distribution of the labor force across skills (the extensive margin) is kept constant. Other contributions do introduce disembodied human capital in the Lucas-Uzawa tradition, but also fail to account for the heterogeneous distribution of skills in the labor force.

economic growth, and how public policy can affect unemployment and its composition. Indeed, accounting for both the demand and supply sides of the labor market is essential to fully understand these issues. Third, only a few contributions (including again Cacciatore and Fiori (2016)) study the impact of labor market reforms on welfare and the possibility that growth and welfare effects may move in opposite directions. This may help to understand (organized) resistance to reform. Moreover, these conflicting effects may also have a temporal dimension, which can be studied only if transitional dynamics are accounted for. Finally, there have been few attempts to assess quantitatively—in terms of unemployment, growth, or welfare—the benefits of a simultaneous implementation of labor market reforms, compared to a piecemeal approach, and the scope for exploiting policy externalities to mitigate the welfare cost of reforms. This matters because the impact of a specific policy may depend on whether other policies are implemented at the same time. Ignoring policy externalities is a potential source of bias.

The purpose of this paper is to address all of these issues, using an overlapping generations (OLG) endogenous growth model with a heterogeneous labor force, final good and innovation sectors, labor market rigidities, and structural unemployment. To model wage formation in final good production, where activity involves more routine tasks and effort is fully observable, trade unions are introduced; but to model wage formation in the innovation sector, an efficiency wage specification is adopted. This approach, as argued elsewhere in the literature, is better suited than standard search models of the Mortensen-Pissarides type to understand the link between wages and productivity in innovation activities. Indeed, in these activities, firms cannot monitor researchers' effort perfectly; the key issue for an employer is thus to mitigate incentives to shirk and encourage creativity. A natural approach is thus to use an efficiency wage framework, in this case linking effort and wages. As a result, persistent uncompetitive wage differentials for highly-skilled workers may emerge across sectors.

While we are able to solve for the balanced growth path, the complexity of our model precludes a full analytical characterization of its dynamic properties. We therefore calibrate it and perform an extensive range of quantitative simulations. Importantly, we calibrate the model for two different groups of countries which are known for facing a range of labor market rigidities (including minimum wages and active trade unions) and

3

have recorded high structural unemployment rates in recent years: a group of high-income European countries and a group of middle-income Latin American countries. In contrast to existing studies, therefore, our experiments allow us to compare systematically the impact of labor market reforms in two significantly different economic environments. We assess the impact of these experiments not only on unemployment, growth, and welfare, but also on the *misallocation of talent*, a situation where individuals with abilities that are high enough to operate in the innovation sector end up instead performing routine production tasks.

In addition to evaluating the effects of single policy experiments, we consider composite programs and examine to what extent policy externalities mitigate the adverse effects of individual reforms. We also consider the cases where composite reform programs are combined with skills expansion and research productivity-enhancing policies, as well as an increase in public investment in infrastructure. Such investments have been advocated in a number of developed and developing countries in the aftermath of the global financial crisis—not only as a short-term Keynesian response due to their demand-side effects, but also as a fundamental step to improve productivity due to their supply-side effects (see for instance LSE Growth Commission (2013) and International Monetary Fund (2016)).

To preview our results, we find that labor market reforms entail a two-way causality between growth and unemployment: growth tends to lower unemployment, through its impact on labor demand; but unemployment may lower growth because it reduces (through its wage signalling effects) incentives to acquire skills and constrains the ability to expand innovation activities—a key engine of growth. Individual labor market reforms may generate a weak correlation between growth and unemployment, as predicted in a number of existing studies; in addition, they may have conflicting effects on growth and welfare in the long run. To some extent, this trade-off can be mitigated by exploiting policy externalities. The scope for labor market reforms to promote innovation and growth, while at the same time improving welfare, reducing unemployment, and tempering the misallocation of talent, is enhanced when they are accompanied by labor productivity-enhancing measures, such as increased research monitoring intensity. In middle-income economies, ambitious reforms aimed at increasing efficiency, both in the public and the private sectors, are particularly important to secure the benefits of labor market reforms.

In addition, public investment in infrastructure may help to boost employment in the short run and mitigate the long-term trade-off between growth and welfare effects associated with labor market reforms. Finally, a comparison of the sum of the long-run effects in terms of growth, unemployment and welfare of each individual policy in a composite program with those associated with the same composite program suggests that, if unemployment or social welfare matters more than growth to policymakers, comprehensive reform programs may generate negative externalities. With limited political capital, overly ambitious labor market reform programs may therefore be costly and ineffective.

The remainder of the paper is organized as follows. Section 2 presents the model. Section 3 defines the balanced growth equilibrium and Section 4 characterizes its properties. Section 5 describes the calibration of the model for "typical" high- and middle-income countries with distorted labor markets and high unemployment. Section 6 considers a variety of individual labor market policies (including a reduction in the minimum wage, a reduction in unemployment benefit rates, and a reduction in the cost of education), as well as policies aimed at increasing labor productivity in innovation and promoting human capital accumulation. Section 7 considers composite reform programs involving a combination of these policies, with and without increases in public investment on infrastructure.[3] The final section provides some concluding remarks.

2   The Model

The economy that we consider is populated by individuals with different innate abilities, who live for two periods, adulthood and old age. Population is constant at $\bar{N}$. Each individual is endowed with one unit of time in each period of life. In old age, time is allocated entirely to leisure. There are four production sectors: a manufacturing sector, which produces a homogeneous final good with routine tasks, an intermediate goods sector, an innovation sector, which creates designs used for producing intermediate goods, and an education sector, which allows individuals to acquire advanced training. The final good is produced by combining both private and public inputs, and is used for consumption, private and public investment, and the production of intermediate goods.

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[3]Appendix C provides a sensitivity analysis with respect to all experiments. The results are quantitatively and qualitatively robust to a significant range of parameter changes.

The public input consists of infrastructure and is provided free of charge.[4] However, it is subject to congestion. Production in the innovation sector combines public and private inputs as well, but workers' effort is not observable.

Firms in the final good and innovation sectors are perfectly competitive whereas those in the intermediate good sector are monopolistically competitive, producing (as in Romer (1990)) differentiated varieties of goods. The total number of blueprints existing at a certain point in time coincides with the number of intermediate input varieties available, and represents the stock of (nonrival) knowledge.

Two categories of labor are available, *untrained* (with only basic education) and *specialized* (with advanced education).[5] Workers are born untrained and must decide at the beginning of adulthood whether or not to become specialized. Acquiring advanced education requires both time and pecuniary costs. While all specialized workers can work in the final good sector, only those with the highest ability can work in the innovation sector, as for instance in Böhm et al. (2015). Rigidities prevail in all segments of the labor market and unemployment emerges in equilibrium.

2.1 Individuals

Individuals have identical preferences but are born with different abilities, indexed by a. Ability is instantly observable by all and follows a continuous distribution with density function $f(a)$ and cumulative distribution function $F(a)$, with support $(0, 1)$. For tractability, a is assumed to be uniformly distributed on its support. Each individual maximizes utility and decides whether to engage in market work as an untrained worker or (after training) as a specialized worker.

Specifically, an adult with ability a can enter the labor force at the beginning of period t as an untrained worker and earn the wage w_t^U, which is independent of the worker's ability. Alternatively, the individual may choose to first spend a fraction $\varepsilon \in (0, 1)$ of his/her time

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[4]As noted later, the model is parameterized separately for both high-income and middle-income countries. For the former group, the public input can be viewed as consisting more of *advanced* infrastructure (high-speed rail, air-traffic control systems, advanced information and communication technologies in general, and high-speed communication networks in particular), whereas for the latter it can be viewed as consisting more of *basic* infrastructure (namely, roads, electricity, and basic telecommunications). See Agénor and Alpaslan (2014) for a discussion.

[5]Formally there are only two periods in the model, but implicitly there is a first period where basic education is acquired.

endowment at the beginning of adulthood in higher education, incur a cost $tc_t > 0$, and then enter the labor force for the remainder of the period as a specialized worker, earning either the wage w_t^{SY} if employed in the final good sector, or w_t^{SR} if employed in the innovation sector. During training, workers earn no income. All individuals can either be employed (superscript E) or unemployed (superscript L). If employed, an untrained individual can work only in the final good sector. All specialized individuals can work in that sector as well, but only those with the highest level of ability, $a > a^R$, can potentially work in the innovation sector. The threshold ability level a^R is taken to be constant, consistent with the assumption that, for any given population, the spread of individuals along the ability continuum is largely determined by nature.[6] If unemployed, individuals earn an unemployment benefit, b_t^h, $h = U, S$, which is not taxable.

Let $c_{t|t+n}^{h,j}$ denote consumption at period $t + n$ of an individual $h = U, SY, SR$, either employed or unemployed, $j = E, L$, born at the beginning of period t, with $n = 0, 1$. The individual's discounted utility function is given by

$$V_t^{h,j} = \eta_C \ln c_{t|t}^{h,j} + \frac{\ln c_{t|t+1}^{h,j}}{1 + \rho}, \quad h = U, SY, SR, \quad j = E, L \tag{1}$$

where $\rho, \eta_C > 0$ are the common discount rate and preference parameter, respectively.[7]

The period-specific budget constraints are given by

$$c_{t|t}^{U,j} + s_t^{Uj} = \begin{cases} (1 - \tau)w_t^U & \text{if } j = Y \\ b_t^U & \text{if } j = L \end{cases}, \tag{2}$$

$$c_{t|t}^{h,j} + s_t^h = \begin{cases} (1 - \tau)[(1 - \varepsilon)w_t^h - tc_t] & \text{if } j = E, \ h = SY, SR \\ (1 - \varepsilon)b_t^S - tc_t & \text{if } j = L \end{cases} \tag{3}$$

$$c_{t|t+1}^{h,j} = (1 + r_{t+1})s_t^h, \quad h = U, SY, SR, \quad j = E, L \tag{4}$$

where $s_t^{h,j}$ is savings, $1 + r_{t+1}$ the gross rate of return between periods t and $t + 1$, and $\tau \in (0, 1)$ the tax rate.

An individual finds it optimal to train if and only if his expected earnings as a specialized worker, adjusted for the time and pecuniary costs of training, exceeds the expected

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[6]Hypotheses such as the Flynn effect in the psychological science literature do suggest that IQ scores tend to improve as the share of the skilled population grows (see Flynn (2007)). However, this remains a contentious subject of research and in the absence of conclusive evidence we treat a^R as fixed.

[7]Because leisure does not enter the utility function, the opportunity cost of unemployment is simply the wage foregone.

earnings of an untrained worker:

$$(1 - \varepsilon)(\zeta_t^{SY} w_t^{SY} + \zeta_t^{SR} w_t^{SR} + \zeta_t^{SL} b_t^S) - tc_t \geq (1 - \zeta_t^{UL}) w_t^U + \zeta_t^{UL} b_t^U, \qquad (5)$$

where the going wage, or the unemployment benefit, is weighted by the respective probability of being either employed or unemployed, $\zeta_t^h \in (0,1)$, for $h = SY, SR, SL, UL$.[8] In specifying (5), we assume for simplicity that an individual knows if his/her ability is above or below the threshold a^C and can therefore decide whether to acquire specialized skills or not at the beginning of adulthood, but finds out whether his/her ability is at or above $a^R > a^C$ only *after* undergoing training. Put differently, this specification captures the idea that an individual discovers whether he/she is "super smart" only upon college graduation—a sensible assumption in practice.[9]

The training cost is proportional to the expected specialized wage when employed and varies inversely with the individual's ability, which determines how fast (or how well) he or she can learn:

$$tc_t = \mu(1 - \varepsilon)(\zeta_t^{SY} w_t^{SY} + \zeta_t^{SR} w_t^{SR})/a^\chi, \qquad (6)$$

with $\mu, \chi \in (0,1)$. The assumption on the productivity parameter χ ensures that the effect of ability on training costs is subject to diminishing returns.

As shown in Appendix A, the threshold level of ability a_t^C such that all individuals with ability higher than a_t^C choose to undergo training is given by

$$a_t^C = \mu^{1/\chi} \left\{ 1 - \frac{(1 - \zeta_t^{UL}) w_t^U + \zeta_t^{UL} b_t^U - (1 - \varepsilon) \zeta_t^{SL} b_t^S}{(1 - \varepsilon)(\zeta_t^{SY} w_t^{SY} + \zeta_t^{SR} w_t^{SR})} \right\}^{-1/\chi}. \qquad (7)$$

This equation plays an important role in understanding the dynamics of the labor market; it shows that labor market outcomes (which are partly influenced by public policy) have a direct impact on the decision to acquire training, through their effect on expected, rather than actual, wages.

The productivity of untrained workers is constant regardless of ability and is normalized to unity. Given (7), the raw supply of untrained labor, N_t^U, is equal to the number

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[8] Equation (5) is assumed to hold as a strict inequality for the individual with the highest ability, that is, $a = 1$, otherwise nobody would choose to become specialized.

[9] Without this assumption two separate conditions, one for those with $a > a^R$ (which would take the form shown in (5), given that these individuals can work anywhere) and one for those with $a < a^R$ (which would exclude the wage in the innovation sector in calculating the expected specialized wage) would be required. This would complicate significantly the analysis, without adding much additional insight.

of individuals in the population who choose not to undergo training:

$$N_t^U = \bar{N} \int_0^{a_t^C} f(a)da = a_t^C \bar{N}. \tag{8}$$

The raw supply of specialized workers with ability $a \in (a_t^C, a^R)$ is $\bar{N} \int_{a_t^C}^{a^R} f(a)da = (a^R - a_t^C)\bar{N}$. However, the average productivity of these workers equals $(a_t^C + a^R)/2$; thus, the effective supply of specialized labor with $a \in (a_t^C, a^R)$ can be defined as

$$\frac{(a^R - a_t^C)(a_t^C + a^R)}{2}\bar{N} = \frac{(a^R)^2 - (a_t^C)^2}{2}\bar{N}. \tag{9}$$

As noted earlier, among specialized workers, only those with ability $a \in (a^R, 1)$ can operate in the innovation sector; thus, the (effective) supply of labor to that segment of the market, N_t^R, is

$$N_t^R = \frac{(1 - a^R)(a^R + 1)}{2}\bar{N} = \frac{1 - (a^R)^2}{2}\bar{N}. \tag{10}$$

Adding (9) and (10), the total (effective) supply of specialized workers, N_t^S, is

$$N_t^S = \frac{1 - (a_t^C)^2}{2}\bar{N}. \tag{11}$$

However, workers with the highest ability are also able to work in the final good sector, at the same wage as other specialized workers there. Assuming that all workers with ability greater than a^R seek employment in innovation activities first, the supply of specialized labor to manufacturing is *not* given by $N_t^S - N_t^R$, but rather by $N_t^S - N_t^{SR}$, where $N_t^{SR} \leq N_t^R$ is the *actual* (demand-determined) level of employment in the innovation sector. Thus, to the extent that $N_t^R > N_t^{SR}$, there is *misallocation of talent*, in the sense that individuals with abilities that are high enough to operate in the innovation sector may end up performing routine tasks in manufacturing. In our numerical experiments we measure talent misallocation by the share of "overqualified" workers in the final good sector, defined as $\max[0, (N_t^R - N_t^{SR})/N_t^{SY}]$, where N_t^{SY} is actual employment in that sector.

2.2   Final Good

Final good production by firm i, Y_t^i, requires the use of specialized labor, $N_{i,t}^{SY}$, untrained labor, $N_{i,t}^{UY}$, private capital, $K_{i,t}^P$, aggregate public capital, K_t^G, and the combination of intermediate inputs, $x_{i,s,t}$, with $s \in (0, M_t)$.

The production function is specified as

$$Y_t^i = [\frac{K_t^G}{(K_t^P)^{\zeta_K} \bar{N}^{\zeta_N}}]^\omega [(1 - \varepsilon) N_{i,t}^{SY}]^{\beta^S} (N_{i,t}^{UY})^{\beta^U} (K_{i,t}^P)^\alpha [\int_0^{M_t} x_{i,s,t}^\eta ds]^{\gamma/\eta}, \qquad (12)$$

where $\beta^S, \beta^U, \alpha, \gamma \in (0,1)$, $\omega > 0$, $\zeta_K, \zeta_N > 0$, $\gamma = 1 - (\beta^S + \beta^U) - \alpha$, $\eta \in (0,1)$ and $1/(1-\eta) > 1$ is (the absolute value of) the price elasticity of demand for each intermediate good, and K_t^P aggregate private capital. Constant returns therefore prevail with respect to private inputs, and public capital is subject to congestion, measured by aggregate private capital and population.

Assuming full depreciation, firm i's profits are defined as

$$\Pi_{i,t}^Y = Y_t^i - \int_0^{M_t} P_t^s x_{i,s,t} ds - (1 + \varsigma_t)[w_t^{SY}(1 - \varepsilon) N_{i,t}^{SY} + w_t^U N_{i,t}^{UY}] - r_t K_{i,t}^P,$$

where $\varsigma_t > 0$ is the firm's contribution rate to the unemployment insurance scheme, based on its total wage bill.

Each firm maximizes profits subject to (12) with respect to labor, private capital, and quantities of intermediate goods $x_{i,s,t}$, $\forall s$, taking factor prices and M_t as given. This yields, in standard fashion,

$$w_t^{SY} = (\frac{\beta^S}{1 + \varsigma_t}) \frac{Y_{i,t}}{(1 - \varepsilon) N_{i,t}^{SY}}, \qquad w_t^U = (\frac{\beta^U}{1 + \varsigma_t}) \frac{Y_{i,t}}{N_{i,t}^{UY}}, \qquad (13)$$

$$r_t = \alpha(\frac{Y_{i,t}}{K_{i,t}^P}), \qquad (14)$$

$$x_{i,s,t} = (\frac{\gamma Z_{i,t}}{P_t^s})^{1/(1-\eta)}, \quad s = 1, ... M_t, \qquad (15)$$

$$Z_{i,t} = Y_{i,t} / \int_0^{M_t} (x_{i,s,t})^\eta ds. \qquad (16)$$

2.3   Intermediate Goods

As in Romer (1990), intermediate goods firms produce inputs based on blueprints produced by the innovation sector. Each firm produces one, and only one, horizontally-differentiated good, using the same technology used to produce the final good. Production of each unit of intermediate goods costs one unit of final output.

Each producer must purchase a patented design from the innovation sector. Once the patent fee Q_t is paid, each producer sets its price to maximize profits, given the

perceived demand function for its good (15), which determines marginal revenue. Under a symmetric equilibrium, profits are given by $\Pi_t^I = (P_t - 1)x_t$ or, using (15) and (16), $\Pi_t^I = (P_t - 1)[\gamma Y_t / P_t M_t x_t^\eta]^{1/(1-\eta)}$. In standard fashion, the solution yields the optimal price as

$$P_t^s = \frac{1}{\eta}. \quad \forall s = 1, ... M_t \tag{17}$$

Using (15), the quantity demanded at this price is $x_{s,t} = (\gamma \eta Z_t)^{1/(1-\eta)}$, $\forall s$, that is, noting that under symmetry $\int_0^{M_t} x_{s,t}^\eta ds = M_t x_t^\eta$,

$$x_t = \gamma \eta (\frac{Y_t}{M_t}), \tag{18}$$

with maximum profit given by

$$\Pi_t^I = (1 - \eta)\gamma(\frac{Y_t}{M_t}). \tag{19}$$

Intermediate-input producing firms last only one period, and patents are auctioned off randomly to a new group of firms in each period. Thus, each firm holds a patent only for the period during which it is bought, implying monopoly profits during that period only; yet patents last forever.[10] By arbitrage, therefore,

$$Q_t = \Pi_t^I. \tag{20}$$

2.4 Innovation Sector

Firms in the innovation sector use only high-ability specialized labor, in quantity $(1 - \varepsilon)N_t^{SR}$. There is no aggregate uncertainty and the production technology is

$$M_{t+1} - M_t = A_t^R[\frac{e_t^R(1 - \varepsilon)N_t^{SR}}{\bar{N}}]^\lambda, \tag{21}$$

where e_t^R is the level of effort and A_t^R productivity, which depends on access to public infrastructure and, consistent with the *standing-on-shoulder* effect (see Jones (2005)), the stock of knowledge:

$$A_t^R = (k_t^G)^{\phi_1^R} M_t, \tag{22}$$

with $k_t^G = K_t^G / K_t^P$ and $\phi_1^R > 0$. Thus, in terms of efficiency units of labor, effort and workers are perfect substitutes. Because of duplication effects there are diminishing

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[10]This assumption simplifies significantly the analysis; see Agénor and Canuto (2015b) for a discussion.

marginal returns to labor, so that $\lambda \in (0, 1)$.[11] Access to public capital is subject to (proportional) congestion, measured by private capital. In addition, to eliminate scale effects, as in Dinopoulos and Segerstrom (1999) innovation difficulty is measured in terms of population size.

Effort is modeled following the simple specification developed in Agénor and Aizenman (1999). In deciding how much effort to provide at t, researchers evaluate a period utility function, $U^R(w_t^{SR}, 1 - e_t^R)$, which depends on the wage earned, w_t^{SR}, and the disutility of effort, $1 - e_t^R$:

$$U^R(w_t^{SR}, 1 - e_t^R) = \ln[(w_t^{SR})^{\delta_R}(1 - e_t^R)^{1-\delta_R}], \tag{23}$$

where $\delta_R \in (0, 1)$. Let π denote the probability that a researcher is caught shirking, in which case he is fired and ends up being either employed in manufacturing, at the going wage w_t^{SY}, or unemployed, collecting the benefit b_t^S. In line with the standard Shapiro-Stiglitz shirking model, we assume that it is related one-to-one with the intensity with which firms in the innovation sector choose to monitor their workers. Thus, although given at the level of each individual researcher, π (or, equivalently here, monitoring intensity) is in principle a choice variable at the level of the firm, which would normally vary inversely with unit monitoring costs. In turn, these costs may depend on both firm-specific characteristics (the required number of supervisors for particular tasks, for instance) and sector- or economy-wide factors. In particular, worker monitoring may be inherently more difficult in innovation activities, because of imperfect observability of creative effort. For the moment, we assume that π is constant.

The level of effort provided is either e_t^R, when employed and not shirking, or the minimum $e_m^R \in (0, 1)$, when shirking while employed. The optimal level of effort is such that the utility derived from working without shirking (as given by (23)) is at least equal to the expected utility of shirking:

$$U^R(w_t^{SR}, 1 - e_t^R) \geq \pi \ln[(\zeta_t^{SY} w_t^{SY} + \zeta_t^{SL} b_t^S)^{\delta_R}(1 - e_m^R)^{1-\delta_R}] \tag{24}$$

$$+(1 - \pi) \ln[(w_t^{SR})^{\delta_R}(1 - e_m^R)^{1-\delta_R}],$$

where the latter is defined as a weighted average of the expected income earned if caught shirking and fired with probability π (either working at the alternative wage w_t^{SY}, with

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[11]See Gancia and Zilibotti (2005) for a discussion. Empirical estimates of λ are discussed later.

probability ζ_t^{SY}, or unemployed, with probability ζ_t^{SL}, and earning the benefit b_t^S) and if not caught with probability $1 - \pi$ (earning the going wage w_t^{SR}). In either case, for simplicity the worker provides the minimum effort level e_m^R.

In equilibrium, workers are indifferent between shirking and not shirking; condition (24) therefore holds with equality and can be solved to give

$$e_t^R = 1 - (1 - e_m^R)(\frac{\zeta_t^{SY} w_t^{SY} + \zeta_t^{SL} b_t^S}{w_t^{SR}})^\psi, \tag{25}$$

with $\psi = \pi \delta_R / (1 - \delta_R)$. Thus, an increase in the expected wage in the innovation sector relative to its opportunity cost raises the level of effort. For a given wage ratio, an increase in the probability of getting caught shirking (a rise in π) raises also the level of effort.[12]

Using (21), and taking the patent fee and productivity as given, the firm's problem is to maximize profits by setting both wages and employment:

$$\max_{N_t^{SR}, w_t^{SR}} \Pi_t^R = Q_t A_t^R [\frac{e_t^R (1 - \varepsilon) N_t^{SR}}{\bar{N}}]^\lambda - (1 + \varsigma_t) w_t^{SR} (1 - \varepsilon) N_t^{SR}, \tag{26}$$

subject to (25). The first-order conditions are given by

$$\lambda (N_t^{SR})^{\lambda-1} (e_t^R)^\lambda (1 - \varepsilon)^\lambda \frac{Q_t A_t^R}{\bar{N}^\lambda} = (1 + \varsigma_t)(1 - \varepsilon) w_t^{SR}, \tag{27}$$

$$\lambda (e_t^R)^{\lambda-1} \frac{Q_t A_t^R}{\bar{N}^\lambda} [(1 - \varepsilon) N_t^{SR}]^\lambda \frac{\psi(1 - e_t^R)}{w_t^{SR}} = (1 + \varsigma_t)(1 - \varepsilon) N_t^{SR}. \tag{28}$$

These equations can be combined to give

$$w_t^{SR} = \kappa^R (\zeta_t^{SY} w_t^{SY} + \zeta_t^{SL} b_t^S), \tag{29}$$

where $\kappa^R = [(1 + \psi)(1 - e_m^R)]^{1/\psi} > 1$.[13] Thus, the efficiency wage is proportional to, and higher than, the (expected) opportunity cost of working in the innovation sector. At the optimal wage, the equilibrium level of effort is constant at $\tilde{e}^R = 1 - (1 - e_m^R)(\kappa^R)^{-\psi} > 0$.

2.5 Government

The government operates both a general budget and an unemployment insurance fund. It cannot issue bonds and must run balanced accounts in both cases. To finance its general

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[12] If effort is independent of relative wages ($\psi = 0$), or if wages are continuously equal in both sectors, then $e_t^R = e_m^R$.

[13] The Solow condition can be established by combining (27) and (28), which yields $w_t^{SR}(e_t^R)'/e_t^R = 1$, where $(e_t^R)' = de_t^R/dw_t^{SR} = \psi(1 - e_t^R)/w_t^{SR}$.

outlays, the government levies a tax on wages at the rate τ. These outlays consist of investment in infrastructure, G_t^I, and spending on other (not directly productive) items, G_t^O. It imposes no fees for its services.

The government's general budget is given by

$$G_t^I + G_t^O = \tau\{w_t^U N_t^{UY} + N_t^{SY}[(1-\varepsilon)w_t^{SY} - tc_t] + N_t^{SR}[(1-\varepsilon)w_t^{SR} - tc_t]\}. \tag{30}$$

Shares of spending are constant fractions of government revenues:

$$G_t^i = \upsilon_i \tau\{w_t^U N_t^{UY} + N_t^{SY}[(1-\varepsilon)w_t^{SY} - tc_t] + N_t^{SR}[(1-\varepsilon)w_t^{SR} - tc_t]\}, \quad i = I, O \tag{31}$$

where $\upsilon_i \in (0,1)$. Combining (30) and (31) therefore yields

$$\upsilon_I + \upsilon_O = 1. \tag{32}$$

Let θ_t^h, $h = UY, SY, SR$, denote the proportion of employed individuals of category h in the adult population $\bar{N}$, and let θ_t^h, $h = UL, SL$, denote the unemployment rate (again, in proportion of $\bar{N}$) of labor category h; the unemployment insurance fund's budget is given by

$$(b_t^U \theta_t^{UL} + b_t^S \theta_t^{SL})\bar{N} = \varsigma_t\{w_t^U \theta_t^{UY} + (1-\varepsilon)(w_t^{SY}\theta_t^{SY} + w_t^{SR}\theta_t^{SR})\}\bar{N},$$

which implies

$$\varsigma_t = \frac{b_t^U \theta_t^{UL} + b_t^S \theta_t^{SL}}{w_t^U \theta_t^{UY} + (1-\varepsilon)(w_t^{SY}\theta_t^{SY} + w_t^{SR}\theta_t^{SR})}. \tag{33}$$

Thus, all else equal, a higher benefit rate (b_t^U or b_t^S) raises the payroll contribution rate, thereby reducing labor demand. In turn, the reduction in labor demand (through a fall in employment ratios) mitigates the initial increase in the contribution rate at the initial unemployment and wage rates.

Assuming full depreciation, the stock of public capital evolves according to

$$K_{t+1}^G = \varphi G_t^I, \tag{34}$$

where $\varphi \in (0,1)$ is an efficiency parameter, which measures the extent to which investment outlays translate into actual public capital (see Agénor (2012)).

To ensure the existence of a nondegenerate solution, the unemployment benefit is set as a linear function of the level of per capita income, so that

$$b_t^h = \kappa^h \frac{Y_t}{\bar{N}}, \tag{35}$$

where $\kappa^h \in (0,1)$, with $h = U, S$, is the benefit indexation parameter.

14

2.6 The Labor Market

Wages in the final good sector are set through a right-to-manage bargaining process between a centralized trade union and firms. The union's objective is to maximize the expected current income of both types of workers in manufacturing, subject to wage and employment targets.[14]

Specifically, the union sets w_t^U and w_t^{SY} with the objective of maximizing a utility function that depends on deviations of both employment and wages from their target levels, subject to the manufacturing sector's demand schedule for each type of labor. Normalizing the employment target to zero, the union's utility function takes the standard form

$$\mathfrak{V}_t^h = (w_t^h - w_t^{hT})^{\xi^h}(N_t^h)^{1-\xi^h},$$

where $h = UY$, SY, $\xi^h \in (0,1)$, and N_t^h is given in (13). The term w_t^{hT} measures the union's target wage, whereas ξ^h reflects the relative importance that the union attaches to wage deviations from that target. Maximizing this function with respect to w_t^h gives the actual wage as a mark-up (which is increasing in ξ^h) over the target wage:[15]

$$w_t^h = \left(\frac{1 - \xi^h}{1 - 2\xi^h}\right)w_t^{hT}. \tag{36}$$

The target wage for untrained workers is related positively to a government-imposed minimum wage, w_t^{UM}, and negatively to the unemployment rate for that category of labor, θ_t^{UL}:

$$w_t^{UT} = w_t^{UM}(\theta_t^{UL})^{-\varkappa^U},$$

where $\varkappa^U > 0$. When unemployment is high, the probability of finding a job (at any given wage) is low. Consequently, the higher the unemployment rate, the greater the incentive for the union to moderate its wage demands in order to induce firms to increase employment.

In turn, the minimum wage is linearly related to the level of per capita income:

$$w_t^{UM} = w_0^U\left(\frac{Y_t}{\bar{N}}\right), \tag{37}$$

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[14]The union's optimization problem is static, in the sense that when it formulates its wage demands it takes the existing capital stock as given and does not internalize the effect of future wages on the firm's decision to accumulate capital—and thus future labor demand. This is tantamount to assuming sequential wage bargaining and the absence of reputational links across periods.

[15]To ensure that $w_t^h > 0$ requires $\xi^h < 0.5$, a condition that we impose in the calibration.

where $w_0^U > 0$ is an indexation parameter.

Substituting the above expressions into (36) therefore yields

$$w_t^U = w_0^U \left(\frac{1 - \xi^U}{1 - 2\xi^U}\right)\left(\frac{Y_t}{\bar{N}}\right)(\theta_t^{UL})^{-\varkappa^U}. \tag{38}$$

The target wage for specialized workers is negatively related as well to the unemployment rate for that category of workers, θ_t^{SL}, and linearly related once again to the level of per capita income, $Y_t/\bar{N}$, so that $w_t^{SYT} = w_0^{SY}(\theta_t^{SL})^{-\varkappa^S}Y_t/\bar{N}$, where $w_0^{SY} > 0$ is an indexation parameter. Inserting this result into (36) yields

$$w_t^{SY} = w_0^{SY}\left(\frac{1 - \xi^{SY}}{1 - 2\xi^{SY}}\right)(\theta_t^{SL})^{-\varkappa^S}\left(\frac{Y_t}{\bar{N}}\right). \tag{39}$$

The equilibrium condition of the market for untrained labor is given by

$$N_t^U = N_t^{UL} + N_t^{UY},$$

where N_t^{UL} is the number of unemployed. Equivalently, in terms of ratios to population,

$$\theta_t^U = \theta_t^{UL} + \theta_t^{UY}, \tag{40}$$

where $\theta_t^U = N_t^U/\bar{N}$, which from (8) is equal to a_t^C. Thus, the probability of employment for an untrained individual, ζ_t^{UY}, and the probability of an untrained individual becoming unemployed, ζ_t^{UL}, are given respectively by

$$\zeta_t^{UY} = \frac{\theta_t^{UY}}{\theta_t^U}, \text{ and } \zeta_t^{UL} = 1 - \zeta_t^{UY} = \frac{\theta_t^{UL}}{\theta_t^U}. \tag{41}$$

The equilibrium condition of the market for (effective) specialized labor is given by:

$$N_t^S = N_t^{SY} + N_t^{SR} + N_t^{SL},$$

or equivalently, in terms of ratios to population,

$$\theta_t^S = \theta_t^{SY} + \theta_t^{SR} + \theta_t^{SL}. \tag{42}$$

The employment and unemployment probabilities for specialized workers are given by

$$\zeta_t^{SY} = \frac{\theta_t^{SY}}{\theta_t^S}, \quad \zeta_t^{SR} = \frac{\theta_t^{SR}}{\theta_t^S}, \quad \text{and } \zeta_t^{SL} = 1 - \zeta_t^{SY} - \zeta_t^{SR} = \frac{\theta_t^{SL}}{\theta_t^S}. \tag{43}$$

16

Figure 1 summarizes the production structure and the sectoral distribution of labor. Although it does not show (for clarity) how employment and unemployment probabilities are determined, it illustrates fairly well how labor market rigidities affect wage formation and unemployment, and the feedback effect of unemployment (through its impact on compensation for the unemployed) on expected wages and the decision to acquire advanced training.

2.7 Savings-Investment Balance

Given full depreciation, the saving-investment balance requires private capital in $t + 1$ to be equal to savings in period t by all individuals, employed or unemployed, born in $t - 1$:

$$K_{t+1}^P = (s_t^{UY} N_t^{UY} + s_t^{UL} N_t^{UL}) + (s_t^{SY} N_t^{SY} + s_t^{SR} N_t^{SR} + s_t^{SL} N_t^{SL}). \qquad (44)$$

3 Balanced Growth Equilibrium

In this economy, an *equilibrium with imperfect competition and unemployment* is a sequence of consumption and saving allocations $\{c_{t|t}^{h,j}, c_{t|t+1}^{h,j}, s_t^{h,j}\}_{t=0}^{\infty}$, for $h = U, SY, SR$, $j = E, L$, prices of production inputs $\{w_t^U, w_t^{SY}, w_t^{SR}, r_{t+1}\}_{t=0}^{\infty}$, private capital $\{K_t^P\}_{t=0}^{\infty}$, public capital $\{K_t^G\}_{t=0}^{\infty}$, existing varieties $\{M_t\}_{t=0}^{\infty}$, prices and quantities of intermediate inputs $\{P_t^s, x_{s,t}\}_{t=0}^{\infty}$, $\forall s \in (0, M_t)$, such that, given initial stocks K_0^P, K_0^G, $M_0 > 0$,

a) all individuals, specialized or untrained, employed or unemployed, maximize utility by choosing consumption subject to their intertemporal budget constraint, taking factor prices, the tax rate, and the unemployment benefit as given;

b) firms in the final good sector maximize profits by choosing labor, private capital, and intermediate inputs, taking factor prices as given;

c) intermediate input producers set prices so as to maximize profits, while internalizing the effect of their decisions on the perceived aggregate demand curve for their product;

d) producers in the innovation sector maximize profits by choosing labor and wages, taking patent prices and productivity as given;

e) the price of each blueprint extracts all profits made by the corresponding intermediate input producer;

f) the trade union in the manufacturing sector sets wages so as to maximize its utility, subject to the demand for labor by firms in the final good sector;

g) the final good market clears; and

h) unemployment of both categories of workers prevails.

A *balanced growth equilibrium* is an equilibrium with imperfect competition and unemployment in which

a) $\{c_{t|t}^{h,j}, c_{t|t+1}^{h,j}, s_t^{h,j}\}_{t=0}^{\infty}$, for $h = U, SY, SR$, $j = E, L$, and K_t^P, K_t^G, Y_t, M_t, w_t^U, w_t^{SY}, w_t^{SR}, b_t^h, $h = U, S$, grow at the constant, endogenous rate $1 + \gamma$, implying that the knowledge-private capital ratio and the public-private capital ratio are constant;

b) the rate of return on capital, $1 + r_{t+1}$, is constant;

c) the price of intermediate goods, P_t, and the patent price, Q_t, are constant;

e) the threshold level of individuals who choose to remain untrained, a_t^C, is constant;

f) the fractions of the specialized and untrained labor force employed in manufacturing, θ_t^{UY} and θ_t^{SY}, and the fraction of specialized workers employed in the innovation sector, θ_t^{SR}, are constant;

g) specialized and untrained unemployment rates, θ_t^{UL} and θ_t^{SL}, are constant; and

h) employment and unemployment probabilities, ζ_t^{UY}, ζ_t^{SY}, ζ_t^{SR}, and ζ_t^{UL}, ζ_t^{SL} are constant.

4   Properties of the Equilibrium

A complete analytical solution of the model is provided in Appendix A. A key step in deriving the equilibrium growth rate is to establish the restrictions needed on the congestion parameters in (12). With $m_t = M_t/K_t^P$ denoting the knowledge-private capital ratio, equation (12) yields

$$Y_t = (1 - \varepsilon)^{\beta^S} (\theta_t^{SY})^{\beta^S} (\theta_t^{UY})^{\beta^U} N_t^{\beta^S + \beta^U - \omega \zeta_N} \tag{45}$$

$$\times (k_t^G)^{\omega} \left\{ \Lambda_1 m_t^{(1-\eta)/\eta} \left(\frac{Y_t}{K_t^P} \right) \right\}^{\gamma} (K_t^P)^{\alpha + \gamma/\eta + \omega(1 - \zeta_K)},$$

where $\Lambda_1 = \gamma\eta$. To ensure that production is linear in the private capital stock, ζ_K and ζ_N must satisfy the conditions $\beta^S + \beta^U - \omega\zeta_N = 0$ and $\alpha + \gamma/\eta + \omega(1 - \zeta_K) = 1$. As a result, the level of output becomes:

$$Y_t = \frac{(k_t^G)^{\omega/(1-\gamma)} \Lambda_2}{[(\theta_t^{SY})^{\beta^S} (\theta_t^{UY})^{\beta^U}]^{-1/(1-\gamma)}} \left\{ m_t^{(1-\eta)/\eta} \right\}^{\gamma/(1-\gamma)} K_t^P, \tag{46}$$

where $\Lambda_2 = (1 - \varepsilon)^{\beta^S} \Lambda_1^{\gamma/(1-\gamma)}$.

In Appendix A we also show that the model can be condensed in the form of a system consisting of two first-order dynamic equations in terms of the knowledge-private capital ratio, m_t, and the public-private capital ratio, k_t^G, as well as 9 core static equations, in terms of the output-private capital ratio, Y_t/K_t^P, the patent price, Q_t, the threshold level of ability (or equivalently the share of untrained workers), a_t^C, the shares of specialized workers in final good production and innovation activities, θ_t^{SY} and θ_t^{SR}, the share of

untrained workers in final good production, θ_t^{UY}, the shares of specialized and untrained workers in unemployment, θ_t^{SL} and θ_t^{UL}, and the payroll contribution rate, ς_t. The steady-state growth rate, $1 + \gamma$, is shown to be given by[16]

$$1 + \gamma = (e^R)^\lambda (1 - \varepsilon)^\lambda (k^G)^{\phi_1^R} (\theta^{SR})^\lambda. \tag{47}$$

Stability of the economy cannot be studied analytically, given the complexity of the system. However, it is established numerically (using the calibration discussed next) by solving the model for a large number of periods and ensuring that the solution values satisfy the properties of the balanced growth equilibrium defined earlier.

5   Calibration

To study the impact of labor market reforms we calibrate two versions of the model, the first corresponding to a "typical" high-income economy, based on averages for five European economies (Belgium, France, Italy, Portugal, and Spain) and the second to a "typical" middle-income economy, based on averages for five upper-income Latin American economies (Argentina, Brazil, Chile, Colombia, and Peru). These two versions allow us to explore the extent to which the effects of labor market reforms depend on structural characteristics. Indeed, beyond the level of income, the countries included in each group share a number of common economic features; in particular, all the Latin American countries have a relatively small innovation sector (both in terms of employment and capacity to create knowledge), whereas all the European countries impose high income tax and payroll contribution rates to finance large redistribution programs. At the same time, countries in both groups are characterized by significant labor market rigidities and high levels of unemployment, caused largely by permanent, structural factors rather than cyclical determinants. The main sources of data are the OECD for European economies and the Inter-American Development Bank, the International Labour Office (ILO), and the World Bank for Latin American countries. For convenience, population is normalized to unity in both cases.

Consider first the high-income economy. On the household side, the annual discount rate is set at 0.04. Assuming that there is an implicit first period (childhood-early adult-

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[16]From the equations in Appendix A, and given that all stock variables grow at the same rate in equilibrium, other equivalent forms for the steady-state growth rate can of course be defined.

hood) that is not accounted for, each period in the model is set to 25 years to match life expectancy data. This gives an intergenerational discount rate of 0.375; the same value is used for the middle-income economy. The household savings rate, σ, is set at 0.1094, based on the average (net) household savings rate estimated using OECD data for 2006-13. The relative cost of specialized training (or tertiary education), μ, and the average time spent in such training, ε, are calibrated using data from *OECD Education at a Glance 2015*. Specifically, for the five countries considered, the expected number of years of full time schooling in tertiary education is 2.86 years. Divided by 25, this gives $\varepsilon = 0.115$. Regarding education expenditure, we use the estimated annual average tuition fees charged by educational institutions in 2013-14. While the OECD publishes a range of values for each country and across public and independent private institutions, we narrow them down to a single range estimate for each country. Then, dividing by the reported average annual wage, the average tuition fee is calculated to be about 6.1-7.7 percent of the average wage. We set μ to a slightly higher value of 0.08 to account for other ancillary expenditure. To account for a high degree of efficiency of training in a developed-economy setting, the parameter χ is set at a high value of 0.9.

In the final good sector, the elasticity of production with respect to the public-private capital ratio, ω, is set at 0.17, in line with the meta-analysis of Bom and Ligthart (2014) and the results of Calderón et al. (2015). The elasticities of output with respect to private capital and labor are set at standard values of $\alpha = 0.3$ and 0.6, respectively, consistent with the evidence (see for instance Afonso and St. Aubyn (2009) and Varga et al. (2014)). We then set $\beta^S = \beta^U = 0.3$, to reflect equal importance of both types of labor in production. Given the assumption of constant returns to scale, the elasticity of output with respect to intermediate inputs, γ, is set at 0.1.

In the intermediate good sector, the substitution parameter, η, is set at 0.61, consistent with the value used by Iacopetta (2011) for instance. This yields an elasticity of substitution between intermediate goods of 2.6, which corresponds to the value estimated by Acemoglu and Ventura (2002).

In the innovation sector, the productivity parameter with respect to public infrastructure, ϕ_1^R, is set at 0.186, based on the estimates of Agénor and Neanidis (2015). The elasticity of design production with respect to labor, λ, is set at 0.6, the same value used

by Varga et al. (2014) for Italy and Spain. It is also within the range of 0.13-0.74 estimated by Pessoa (2005) for OECD countries. The elasticity of effort with respect to relative wages, ψ, is set at 0.7, slightly higher than the value used by Wauthy and Zenou (1997). To capture the idea that researchers in innovation value wages more than leisure, we set $\delta_R = 0.9$ for the elasticity parameter in the second-stage utility function. This yields a probability of getting caught shirking of $\pi = 0.078$. With a minimum research effort of $e_m^R = 0.1$, this yields a value of 1.46 for the composite parameter κ^R; consequently equilibrium effort is $e^R = 0.31$.

For the government, the effective tax rate on wages, τ, is calculated in two steps, based on OECD tax statistics. First, taxes on household factor income are estimated by calculating total tax revenues net of taxes on property, goods and services, and social security contributions. As a share of GDP, this gives an average of 11.9 percent for the period 2006-13.[17] Second, this number is divided by the total labor share $\beta^S + \beta^U = 0.6$ to give $\tau = 0.198$. To calculate the initial share of public investment on infrastructure in total (noninterest) spending, υ_I, we also proceed in two steps. First, using combined OECD data on non-ICT infrastructure investment and ICT investment for the years 2006-13, the average percentage of (total) infrastructure investment to GDP across the sample economies is estimated at 0.0106. Second, this estimate is divided by the average share of noninterest expenditure in GDP for the same period, as estimated from OECD data, which is 0.4972. This yields $\upsilon_I = 0.021$, or equivalently 1.1 percent of GDP. Lastly, the efficiency parameter of government investment, φ, is calibrated using the "wastefulness of government spending" indicator in the *Global Competitiveness Report* index compiled by the World Economic Forum, which is consistent with the methodology used by the European Commission. This yields $\varphi = 0.5$. This value is rather on the low side for a high-income economy but is consistent with the informal evidence on comparative public sector efficiency in Afonso et al. (2003) for instance, who identified Italy, Portugal, and Spain as among the most inefficient among the 23 developed economies in their sample.

In the labor market the benefit indexation parameters, κ^U and κ^S, are both set equal to 0.4, in line with values used in models with unemployment insurance, such as Heer and Morgenstern (2005). Given (35), this means that the initial values of b^S and b^U are the

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[17]Given the OECD's revenue classification system, this is equivalent to calculating taxes on household income by adding up income taxes and taxes on workforce and payroll.

same. For the union bargaining parameters, ξ^U and ξ^{SY}, we start with the estimates of Blanchflower and Bryson (2002), which give an average union wage mark-up of 1.069.[18] Using this value, estimates for ξ^U and ξ^{SY} can be derived by solving (36) backward; this gives $\xi^U = \xi^{SY} = 0.06$. In terms of the elasticity of the union's target wage with respect to unemployment, $\varkappa^h$, $h = U, S$, Montuenga et al. (2003) estimate the wage elasticity with respect to the unemployment rate for four of the European economies in our sample (with the exception of Belgium); this yields an average value of -0.12. In the absence of skills-specific estimates, we set $\varkappa^U = \varkappa^S = 0.12$. The shift parameter w_0^U is solved implicitly from the minimum wage equation (37), based on OECD data on monthly minimum wages relative to monthly average earnings (as a proxy for monthly income per capita); this gives 0.522. The shift parameter w_0^{SY} in (39) is solved for in the same manner, using data on monthly earnings for skilled workers, after accounting for the average gap in earnings dispersion provided in the OECD's *Employment Database*. This gives $w_0^{SY} = 0.74$.

These values are all summarized in Table 1. Initial steady-state values are shown in Table 2 and are calibrated as follows.

The share of untrained workers in the adult population, θ^U, is set equal to 0.732, which is calculated by subtracting the average share of workers with tertiary education (obtained from OECD data) from unity. Hence, $\theta^S = 0.232$. The share of effective specialized workers in the innovation sector, θ^{SR}, is set equal to 0.0194, based on the OECD's consolidated data on (private and government) researchers. The share of unemployed specialized workers in the population, θ^{SL}, is set at 0.068, which corresponds to the value provided by the OECD's *World Indicators of Skills for Employment* data for skilled unemployment over the period 2006-13. By implication the share of effective specialized workers in the final good sector, θ^{SY}, is equal to 0.145. Based on the same OECD data, the untrained unemployment rate, θ^{UL}, is set equal at 0.126, corresponding to the average, group-specific unskilled unemployment rate. By implication, the share of untrained workers in the final good sector, θ^{UY}, is 0.606. The probabilities in (41) and (43) are then easily calculated and are also reported in Table 2. The aggregate unemployment rate can also be easily derived, given relative shares of untrained and specialized workers in the

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[18] For France, the more recent results of Breda (2015) corroborate the Blanchflower-Bryson estimate.

work force; this gives 0.1058. To estimate the misallocation of talent, we use the average value over 2006-13 from OECD data on the proportion of workers who are overqualified, which is equal to 0.189.[19] Based on that value, the potential supply of specialized labor to that segment of the market, θ^R, can be estimated backward using the definition of the share of "overqualified" workers in the final good sector, $(\theta^R - \theta^{SR})/\theta^{SY}$. Given that $\theta_t^{SR} = 0.0194$ and $\theta_t^{SY} = 0.145$, this yields $\theta^R = 0.189 \cdot 0.145 + 0.0194 = 0.0467$. By implication, the threshold value of ability to work in the innovation sector is solved from (10) to give $a^R = 0.952$. For the firms' payroll contribution rate, ς, the average employers' contribution rate of the five economies obtained from the OECD *Social Security Dataset* is used; this gives $\varsigma = 0.126$. Using the OECD's relative earnings data by education gap for 2012 (low and medium-skilled workers on the one hand, and high-skilled workers on the other), the untrained-specialized wage ratio is calibrated at 0.55; the inverse of this ratio gives a wage premium of 1.818. The public-private capital ratio, k^G, is set based on Kamps' (2006) estimates of public and private capital stocks, yielding $k^G = 0.189$. Using OECD data, the average final output-private capital ratio is calculated as $Y/K^P = 0.286$. An initial estimate of the knowledge-private capital ratio, m, is difficult to construct, given that the two variables are in principle measured in different units (the number of patents for instance for the stock of knowledge, and cumulated real investment spending, through an efficiency-adjusted, perpetual inventory method, for the capital stock). Given that this initial ratio is immaterial to the results, we normalize it to 0.1 largely for computational convenience. The growth rates of final output and physical capital in the initial steady state are 0.8 percent on an annual basis, based on the GDP-weighted average growth rates of the five economies during 2006-13.

Consider now the typical middle-income country. To capture some relevant stylized facts for these economies, its baseline calibration needs some distinctive structural characteristics. Given the issues at stake, we highlight the following features. First, it is more costly, and less efficient, for a worker to train and become specialized. Second, due to relative scarcity, the elasticity of final good production with respect to specialized workers is higher, and there is less substitutability among intermediate goods. Third, the share of

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[19]The data is based on OECD calculations using the EU Labour Force Survey. Based on OECD definition, the published figures reflect the "*proportion of workers whose educational attainment level is higher than the level required in their job (as measured based on the modal education level for all workers in the same occupation)*".

public spending on infrastructure is higher but investment (as a result of poor governance) is less efficient. At the same time, the elasticity of manufacturing output with respect to public capital is higher, to reflect stronger marginal benefits due to a lower initial stock of infrastructure assets. Fourth, the innovation sector (as measured by the number of researchers) is smaller and workers are subject to less intense monitoring. Quantitatively, the differences that these features lead to, as well as other differences in terms of initial values (as discussed next), are shown in Tables 1 and 2 as well.

On the household side, estimates based on household surveys by Gandelman (2015) are used to set the savings rate σ at 0.138. The average school life expectancy at tertiary level for the five Latin American economies is 3.07 years, which gives $\varepsilon = 0.123$. To account for more costly and less efficient training, and in the absence of data similar to those referred to earlier for the high-income economy, the training cost μ is set at 0.12, and the efficiency of training χ at 0.5. In the final good sector, the elasticity of production with respect to the public-private capital ratio ω is set at 0.24, in line with the general equilibrium estimates of Agénor and Neanidis (2015). The elasticity parameter with respect to private capital, α, is set equal to 0.35. This is the average value for the five Latin American economies used for instance in the growth accounting exercises of Loayza et al. (2005). Following Agénor and Alpaslan (2014), we set $\beta^U = 0.20$ and $\beta^S = 0.35$, so that $\gamma = 0.1$ again. The implied private capital/labor share, 0.35/0.55, is consistent with a 0.4/0.6 ratio used in some models without intermediate goods.[20]

In the intermediate good sector, the substitution parameter, η, is set at 0.25, which corresponds to the value used by Agénor and Neanidis (2015) to examine innovation-driven growth in a developing-economy context. This value implies therefore a lower elasticity of substitution (about 1.33) between intermediate goods than before. In the same vein, in the innovation sector ϕ_1^R is set at 0.3, which is consistent with the initial calibration and the higher range of estimates obtained by Agénor and Neanidis (2015). To capture lower research monitoring intensity, the probability of being caught shirking is set 3 percentage points lower than in the high-income economy, so that $\pi = 0.048$. This yields $\psi = 0.43$ and an equilibrium effort level of $e^R = 0.143$, which is about half the value calibrated for the high-income economy.

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[20]See Agénor and Canuto (2015a) for Brazil, and Ferreira et al. (2013) for Latin America.

For the government, a similar calibration strategy based on the same sources (OECD *tax revenue statistics* for Latin America, and *Global Competitiveness Index*) is used to estimate the effective tax rate, τ, and the efficiency of public investment, φ. These calculations give averages of $\tau = 0.123$ and $\varphi = 0.4$. This estimate of φ is close to the median value obtained by Dabla-Norris et al. (2012) in their study of the efficiency of public investment in developing countries. The share of public spending on infrastructure, υ_I, is estimated in two steps, based on the data on total infrastructure investment as a proportion of GDP compiled by Calderon and Servén (2010) and Carranza et al. (2014). The private component of total investment, obtained from the World Bank's *Private Participation in Infrastructure* Database, is first subtracted to obtain the share of public infrastructure investment as a proportion of GDP. This figure is then multiplied by the inverse of the ratio of non-interest government expenditure to GDP to obtain an estimate of υ_I for each of the five Latin American economies. The average value for the five economies for the period 2006-13 gives $\upsilon_I = 0.069$, or equivalently 2.0 percent of GDP. Regarding the labor market, in the absence of reliable estimates, the same values of $\varkappa^U$ and $\varkappa^S$ as given earlier are used. The minimum wage shift parameter, w_0^U, is again calibrated based on the average ratio of the gross monthly minimum wage over gross monthly earnings, as provided in ILO Statistics. This gives $w_0^U = 0.546$. For w_0^{SY}, the median wage differentials between secondary-primary and secondary-tertiary are used (see Inter-American Development Bank (2004, Table 1.8)) to estimate an average value for wage dispersion in the five Latin American economies. This yields 0.153, which implies, solving again (39) implicitly, $w_0^{SY} = 0.699$. This also means that the initial wage gap for workers in the final good sector is smaller in the high-income economy. In terms of unemployment benefits (which cover in reality a fairly limited number of workers), estimates by Cortazar (2001) and Ferrer and Riddell (2009) suggest that for the group of countries under consideration unemployment insurance represents from 0.12 to 2.5 times the minimum wage. Multiplying by $w_0^U = 0.546$ yields a range of 0.06-0.82 for κ^U and κ^S. Mid-range values of $\kappa^U = \kappa^S = 0.4$ are used initially. Lastly, for the union wage mark-up, the Inter-American Development Bank (2004) documents that unions in South America increase their members' earnings by anywhere between 5 and 10 percent. Setting the wage mark-up to 1.1, and again solving (36) backward yields $\xi^U = \xi^{SY} = 0.08$.

In terms of initial steady-state values, the labor shares are estimated using data from ILO and the World Bank. The share of untrained workers in the population, θ^U, is set equal to 0.795, which yields $\theta^S = 0.184$. The share of effective specialized workers in innovation, θ^{SR}, is estimated by dividing the average number of researchers over the total workforce for the five economies over 2006-13, yielding $\theta^{SR} = 0.004$. The share of unemployed specialized workers, θ^{SL}, is set equal to 0.071, based on ILO data. By implication, $\theta^{SY} = 0.109$. The unemployment rate for untrained workers, θ^{UL}, is also obtained from ILO data and is set at 0.087. These data therefore imply that $\theta^{UY} = 0.708$, and the aggregate unemployment rate is now 0.0791. In the absence of OECD-type data on the proportion of "overqualified" workers in Latin America, we set the ability threshold a^R (and therefore θ^R, as implied by (10)) at the same value as in the high-income economy, 0.952. The initial degree of talent misallocation can thus be solved backward from $(\theta^R - \theta^{SR})/\theta^{SY}$, to give 0.392. This implies that there are a lot more overqualified workers in the final good sector of the middle-income economy, consistent with recent theories of middle-income traps (see Agénor (2016)). The firms' payroll contribution rate, ς, is set at 0.052.[21] The initial relative wage ratio is estimated at 0.75 based on ILO data, implying that the initial expected wage premium is now lower, at 1.333. The public-private capital ratio calculated for Brazil by Agénor and Canuto (2015a), $k^G = 0.147$, is used as a proxy for the group average. The final output-private capital ratio, Y/K^P, is calibrated using the private capital-GDP ratios for Argentina, Brazil and Chile estimated by Tafunell and Ducoing (2016). This yields $Y/K^P = 0.429$. The knowledge-private capital ratio, m, is again normalized to 0.1. Lastly, the annual growth rates for final output and capital in the initial steady state are equal to 3.9 percent, based on the GDP-weighted average growth rate of the five economies during 2006-13.

Based on Tables 1 and 2, and consistent with our earlier discussion, the key differences between the middle-income economy and the high-income economy can be summarized as follows: a) higher efficiency and lower cost of training in the high-income economy; b) a lower degree of substitution between intermediate goods in the middle-income economy; c) higher elasticities of final output and innovation activity with respect to public capital

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[21]While payroll taxes represent on average of 31 percent of wages in Latin America (see Lora and Fajardo (2012)), only the portion that employers contribute to the unemployment/severance fund is accounted for here.

in the middle-income economy; d) a higher share of specialized workers in the population and in the innovation sector in the high-income economy; e) a higher open unemployment rate for untrained (specialized) workers in the high- (middle-) income economy; f) a higher degree of misallocation of talent in the middle-income economy; g) a higher payroll contribution rate in the high-income economy; and h) higher public-private capital and final output-private capital ratios in the high-income economy.[22]

6 Policy Experiments

We now consider a series of individual labor market policies—a reduction in the minimum wage, a cut in unemployment benefit rates, and a reduction in the union's wage mark-up. In addition, we also consider a policy aimed at increasing labor productivity in the innovation sector (a subsidy aimed at inducing firms to increase research monitoring intensity), and a policy aimed at promoting the accumulation of human capital (a cut in training cost). These policies have been discussed extensively in recent years, in both developed and developing countries.[23] All shocks are permanent and their impact is measured in terms of a few key variables—the supply of untrained workers, the effective supply of specialized workers (both total and in the innovation sector), the expected wage premium (which determines training decisions), unemployment rates (total and for both categories of workers), the payroll contribution rate, and the growth rate of final output.

To measure the efficiency gains of reforms in terms of factor allocation, the index of misallocation of talent defined earlier is used. To measure welfare, discounted utility across an infinite sequence of generations is used (see De la Croix and Michel, 2002, p. 91):

$$\mathcal{W}_t = 0.2 \sum_{h=0}^{\infty} \Lambda^h (V_{t+s}^{U,E} + V_{t+h}^{U,L} + V_{t+h}^{SY,E} + V_{t+h}^{SR,E} + V_{t+h}^{S,L}), \qquad (48)$$

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[22]Another important structural difference between the two types of economies is the share of spending on R&D: Latin American countries spend much less than European countries in that area (see Inter-American Development Bank (2014)). Given the focus of this paper we did not explicitly account for that component of public spending or other measures aimed at stimulating R&D (such as tax credits or "matching grants" subsidies). Note also that, consistent with the evidence, for the middle-income country innovation is perhaps best understood as imitation (adaptation of imported technologies) with the patent price being akin to a a license fee paid by intermediate goods producers.

[23]See Inter-American Development Bank (2004), World Bank (2012a, 2012b), Adascalitei and Pignatti Morano (2015) and International Monetary Fund (2016) for instance.

where $\Lambda \in (0, 1)$ is the social discount factor and $V_t^{h,j}$ is the indirect utility function for agent j, h at t, where $h = U, SY, SR$ and $j = E, L$. Thus, the utility of agents in each generation in all five states in the labor market—untrained workers employed or unemployed, specialized workers employed in the final good sector and innovation activities or unemployed—are equally weighted.[24] For tractability, we restrict our analysis to the balanced growth path; Appendix B provides an approximation to (48) along that path, with Λ set to the same value used for households.

Simulation results (impact and steady-state effects) are summarized in Table 3 for the high-income economy and in Table 4 for the middle-income economy, whereas Figure 2 shows the steady-state effects for all experiments.[25] As noted earlier, a period corresponds in principle to a generation in our OLG structure. This is reflected, in particular, in the calibration of the discount factor, household time allocation, and the assumption of full depreciation of physical capital. However, all of the other parameters and variables (including the growth rate of output) either do not have a time dimension or are calibrated on the basis of average annual data; thus, for the numerical experiments, the intended length of a unit of time is best understood as one year.

6.1   Reduction in Minimum Wage

Consider a reduction in the minimum wage, measured by a 5 percent drop in the shift parameter w_0^U. The reduction in the cost of untrained labor increases demand not only for that category of workers but also (due to gross complementarity) for specialized labor in manufacturing. At the initial level of wages, the unemployment rate falls and the employment probability rises for both categories of workers. However, the expected wage for specialized workers increases by more than the expected wage for untrained workers, thereby creating incentives to invest in advanced training. The proportion of untrained (specialized) workers therefore falls (increases) on impact. The increase in specialized employment occurs in both the final good and innovation sectors, though in the middle-income economy, not all specialized labor from the expansion are absorbed, resulting

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[24] Alternatively, time-varying weights, based on period-specific relative shares of each group of workers in the labor force, could be used. However, this implies that groups are not treated equally (because of labor reallocation effects) and could impart significant bias to the results.

[25] Graphical illustrations of the transitional dynamics for the individual policy experiments are provided in Appendix C.

in a slight increase in long-run specialized unemployment rate. The long-run drop in unemployment is particularly large for untrained workers, of the order of 2.8 percentage points for the high-income economy and 2.0 percent for the middle-income economy.

Higher employment for both types of workers translate into a reduction in the payroll contribution rate, which magnifies the expansion in labor demand in manufacturing. Although the initial fall in unemployment tends to raise the union's target wages in the manufacturing sector—thereby mitigating the initial effect of a lower minimum wage—the increased demand for both types of workers tends to promote activity and economic growth, both on impact and in the long run. However, the long-run effects are fairly small in both economies.

Higher wages for specialized workers in manufacturing imply higher wages in the innovation sector as well, to maintain effort there. This helps to increase the share of that type of labor engaged in innovation activity, thereby mitigating the misallocation of talent, by a magnitude of 0.9 and 0.4 percentage points in the long-run for the high- and middle-income economy, respectively. In addition, welfare improves moderately in both cases. In terms of their magnitude, both results reflect a small increase in employment in the innovation sector, a weak effect on the expansion of varieties of intermediate goods, and therefore a small impact on growth in the long run. Overall, lower minimum wages do not necessarily harm growth and welfare—in contrast to the predictions of some small analytical models, such as Cahuc and Michel (1996)—but their effects on these variables, given our calibration, are not quantitatively large.

6.2   Reduction in Unemployment Benefit Rates

We consider three separate experiments with respect to a scaling down in unemployment benefit indexation: a) a reduction in the indexation parameter for only untrained workers, b) a reduction for only specialized workers, and c) a reduction for both type of workers. Specifically, we consider cuts in κ^U and κ^S by 10 percent (from 0.40 to 0.36) each, and a joint reduction in κ^U and κ^S of the same magnitude. These experiments allow us to examine and compare the effects of asymmetric adjustments in unemployment insurance schemes, as well as the case of an across-the-board reform.

A reduction in the benefit rate for untrained workers lowers their expected wage at the

initial level of employment. It therefore raises the education premium and incentives to undergo training. As a result, the share of untrained (specialized) workers falls (increases). The opposite occurs for a reduction in the benefit rate for specialized workers. However, in both cases aggregate unemployment falls—more so for the high-income economy—both on impact and in the long run. This stems from the fact that the direct effect of a lower wage is (as a result of gross complementarity) to stimulate the demand for both types of labor. This effect, which is magnified by a reduction in the payroll contribution rate needed to ensure that the unemployment fund's budget is balanced, persists over time as well. However, unlike the more efficient high-income economy, for the middle-income economy long run specialized (untrained) unemployment rate increases slightly when the indexation parameter is reduced for the untrained (specialized) workers. This is due to a weaker gross complementarity effect and a smaller expansion in the innovation sector, which mitigates its capacity to absorb the increase in specialized labor.

On impact, the growth rate of final output falls in both types of economies. The reason is that the drop in benefits for the unemployed has an adverse effect on savings, which reduces investment and capital accumulation in the short run. Over time, however, two offsetting general equilibrium effects kick in: lower benefits (for untrained workers) improve incentives for individuals to acquire training, whereas a lower contribution rate raises labor demand. In the long run the net effect of the policy is in fact positive—albeit fairly weak for both economies. Although talent misallocation is mitigated, welfare falls in both cases (for either shock) essentially because the unemployed are worse off. The joint reduction in unemployment benefit indexation gives results that are qualitatively similar to those obtained in the individual experiments, and in this instance, unemployment falls—both at the aggregate level and its components—for both types of economies.

The conflicting effect on long-run growth and welfare has not been documented in previous contributions. It suggests that a reduction in unemployment benefit indexation, while effective in terms of reducing unemployment for both types of labor, may need to be accompanied by other measures aimed at mitigating their potential adverse impact on household well-being.

6.3 Reduction in the Union's Wage Mark-Up

Consider a large reduction in the mark-up over the target wage for both untrained and specialized workers, as measured by the parameters ξ^U and ξ^{SY}, respectively (see (36)). This experiment involves a uniform 37.5 percent cut in these parameters, from 0.06 to 0.0375 for the high-income economy and from 0.08 to 0.05 for the middle-income economy. By implication, the union wage mark-up over the target wage (for both untrained and specialized workers) drops by 2.6 percent in the former and by 3.6 percent in the latter.

In both cases unemployment rates for the two types of workers are lower in the short run. However, similar to the previous experiments, for the middle-income economy this labor market policy targeted at untrained (specialized) workers is again ineffective in reducing unemployment of specialized (untrained) workers due to a weaker gross complementarity between the two types of labor. In both economies, the benefits in terms of short-term growth are substantially higher for the mark-up reduction for specialized workers, but in the long run the unemployment and growth effects (although qualitatively similar to the short-run effects) are fairly small. For both types of economies, welfare deteriorates when the mark-up for specialized workers is reduced, but improves slightly when the mark-up for untrained workers is lowered. Again, these results suggest that, taken in isolation, these policies do not have substantial effects on growth and unemployment in the long run, and maybe detrimental to welfare.

6.4 Increase in Labor Productivity in Innovation

Consider a policy aimed at boosting labor productivity in the innovation sector. We assume that this policy takes the form of an across-the-board public subsidy to firms in that sector, which leads directly to a reduction in unit monitoring costs and an increase in monitoring intensity—through improved use of performance indicators and evaluation scorecards, more frequent peer reviews and performance audits, and so on, in line with the "new thinking" on performance management systems. In turn, higher monitoring intensity, given the one-to-one relationship alluded to earlier, translates into a higher probability of a research worker getting caught shirking.[26] Moreover, we assume that

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[26]See Buckingham and Goodall (2015) for a discussion of current approaches to performance management. A more rigorous analysis of the link between public subsidies and firm-level monitoring would obviously need to provide more explicit microfoundations of the firm's decision to monitor, in a setting

these subsidies are financed by a reallocation of spending within other government outlays, G_t^O. Thus, the policy has no direct fiscal implications and can be studied independently from changes in public expenditure. In the high-income case, we assume that this leads to an increase in π from 0.078 to 0.10, whereas for the middle-income economy, the same percentage change leads to an increase in π from 0.048 to 0.061. Thus, although the increase in π is fairly large in relative terms, the new absolute values of the detection probability remain quite small in both cases.

At the initial level of effort, a higher detection probability allows firms to lower the efficiency wage paid to researchers. This reflects the well-known trade-off between monitoring and wages, when both are choice variables for the firm, as alternative ways to elicit effort (see for instance, van Schaik and de Groot (2000)). By implication, and given the downward-sloping labor demand curve for specialized research workers, labor demand rises in the innovation sector. This mitigates the misallocation of talent and generates major benefits for the economy at large—higher effective labor in research activities increases the production of ideas and, consequently, the level of final output, which sets in motion a cycle of higher savings, investment, and growth. The economic expansion tends to reduce the unemployment rates for both types of workers.

From (39), the initial reduction in the specialized unemployment rate and the higher level of activity in the final good sector put upward pressure on specialized wages in manufacturing. Similarly, from (35), higher income per capita also leads to an increase in unemployment benefits for both categories of workers. From the wage-setting condition (29), the specialized wage for research workers must increase as well. The net, initial effect of these changes on the expected wage premium is positive for both types of economies. This, in turn, induces more individuals to engage in training. In the long run, the reduction in the specialized unemployment rate is mitigated due to the increase in labor supply, but the economy expands by 1.3 percentage points for the high-income economy and by 0.3 percentage points for the middle-income economy. Social welfare also improves.

While these effects are qualitatively the same for both types of economies, they are generally weaker for the middle-income economy. In particular, the weak effect on growth

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wherre monitoring costs are not only specific to the firm but also related through an externality to sector-wide factors—which are given at the level of the firm but may be influenced by public policy. For our purpose, however, this reduced-form specificiation is sufficient to illustrate the effects at play.

in the latter case is due to the fact that, in the long run, the expected wage premium actually falls, thereby mitigating incentives to acquire skills. In addition, the increase in the effective supply of specialized workers in the innovation sector is fairly small; in turn, this is because there is a substantial initial gap between the two types of economies in terms of the probability of research workers getting caught when shirking, as discussed earlier. Nevertheless, and in contrast to some of the pure labor market policies considered earlier, this policy is one of the most effective in terms of promoting growth, employment, and welfare, with no direct conflict in the long-run between these objectives.

6.5 Reduction in Training Cost

Finally, consider a policy designed to reduce across the board the cost of specialized training for individuals, paid for by a reallocation of outlays within the unproductive component of public spending. The policy once again has no direct fiscal effects and is measured by a reduction in μ by 5 percent, from 0.080 to 0.076 for the high-income economy and from 0.120 to 0.114 for the middle-income economy. The size of this shock is sufficient to illustrate the issues at stake.

A reduction in training costs generates a large increase in the supply of specialized workers (by 1.6 and 3.3 percentage points in the long run, respectively, for the high- and middle-income economies), a fraction of which being absorbed in the innovation sector. This increase in supply occurs despite the mitigating effect on wages for that category of workers and a drop in the expected wage premium. The reduction in the share of untrained workers has a sizable effect on their unemployment rate; however, the large increase in the supply of specialized workers leads over time to a higher unemployment rate for them (by 1.0 and 2.7 percentage points in the long run for the high- and middle-income economies, respectively). The thrust of these results is that, in both types of economies, promoting human capital accumulation without adequate measures aimed at encouraging simultaneously a sustained expansion in labor demand may create an *absorption problem* or *oversupply* of specialized labor in the long run.

In addition, the effect on the rate of economic growth is small on impact in both types of economies and, in the case of the middle-income economy, growth is weaker in the long run. The reason, as noted earlier, is that the net benefit of an increase in the

supply of specialized workers is muted, due to a smaller expansion in labor demand in the innovation sector. The larger increase in the specialized unemployment rate in the middle-income economy also results in a higher payroll contribution rate, which mitigates the increase in labor demand and dampens steady-state growth. Nevertheless, despite the increase in specialized unemployment, welfare improves for both types of economies because employed untrained workers and both types of unemployed workers gain from this policy. For the former, this is because wages are ultimately higher than initially. For the unemployed, this is because unemployment benefits are higher along the equilibrium path, due to higher steady-state growth.

The negative correlation between the incentive to acquire skills and the supply of specialized workers induced by a reduction in the cost of training, as predicted here, is consistent with the evidence on the inverse association between increases in the number of university graduates and the wage premium provided by Machin and McNally (2007) for Spain—one of the countries in our sample of high-income economies—and New Zealand. Although they do not link it explicitly with a government-induced, sustained reduction in the real *effective* cost of higher education (a broader interpretation of a lower μ in the experiment), the evidence for both countries is consistent with it.[27]

Evidence supportive of the possibility that more university graduates may lead to higher *open* unemployment, as also predicted here, is more difficult to come by for at least three reasons–which are equally relevant for high- and middle-income countries. First, higher unemployment rates for new university graduates often result from mismatches between supply and demand for particular skills (for instance, liberal arts), or low quality standards—an important problem in Latin America, as noted by Yamada (2015)—rather than an across-the-board lack of demand for labor, as predicted by our

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[27] Although we were unable to find publicly available statistics on real effective cost of higher education and its evolution over time, in the case of Spain for instance, two specific educational policies—*Ley Orgánica, de Reforma Universitaria* in 1983 and "*Informe sobre la financiación de las universidades*" in 1994—led directly to the establishment of student financial aid system and the reduction of tuition fees. These, coupled with the large subsequent increase in the number of public universities (the total number of universities increased from 35 in 1985 to 78 in 2010, and the majority of these are public universities) would almost certainly result in a significantly decrease in the real effective cost of tertiary education—consistent with our experiment. In practice, however, an increase in the number of university graduates may also result from improving high school enrollment and completion rates (especially for middle-income countries) or sustained increases in per capita income, which translates into a higher demand for education.

experiment. Second, rather than open unemployment, in practice university graduates may choose to be employed in occupations that do not fully exploit their skill levels, which therefore translates into underemployment or disguised unemployment.[28] Finally, graduates may also choose to migrate abroad, a form of brain drain. Although the model does not explicitly capture any of these possibilities it does nevertheless draw attention to the adverse labor market effects of an oversupply of skills, due to a low effective cost of education promoted by government subsidies. Social demands to expand access to higher education may ultimately prove counterproductive.

7   Composite Reform Programs

The foregoing analysis suggests that reforms may entail dynamic trade-offs: they can have adverse effects on the labor market and growth in the short run, despite improving these outcomes in the long run. This trade-off could induce a government motivated by short-term electoral considerations to postpone, or abandon altogether, the implementation of structural reforms. In addition, growth and welfare may move in opposite directions in the long run, as illustrated in the case of a reduction in the degree of indexation of unemployment benefits, and a cut in the trade union's mark-up on specialized workers' wage target. A natural issue to address therefore is to what extent a combination of measures—assuming that it is politically feasible—can, by exploiting policy externalities, mitigate the contrasting effects associated with individual reforms.

Accordingly, we now consider alternative composite reform programs involving a combination of the individual policies discussed earlier. In addition, we examine the extent to which composite programs designed to reduce unemployment and promote growth would benefit from an increase in public infrastructure investment. This issue has been much discussed in recent years, in the context of persistent, ultra-low interest rates in the global economy.[29]

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[28]The possibility that underemployment may result from *overeducation* is the subject of an extensive microeconomic literature reviewed by Leuven and Oosterbeek (2011), who also documented its incidence in Europe and Latin America.

[29]The European Commission for instance has ambitious deployment targets for high-speed, fiber-based broadband networks in its 2020 strategy. Many observers have argued that public funding is necessary to achieve ubiquitous coverage in remote and unprofitable regions, as opposed to densely populated areas; see Briglauer et al. (2016) for a discussion. In Latin America basic infrastructure needs (including core internet access) remain large and calls for higher public investment have also been vocal; see Serebrisky

7.1   Core Programs

Three core composite reform programs are considered first. In all of them we assume that the key objectives of policymakers are to reduce unemployment and to promote skills acquisition to support innovation-driven growth. Given that the distribution of high-ability individuals in the population is fixed, the latter objective can be achieved only by raising the productivity of those currently employed in the innovation sector, in order to induce higher wages and reduce the misallocation of talent. The combination of policies considered, although fairly targeted (given our focus on structural, rather than cyclical, unemployment), is consistent with long-standing calls for comprehensive programs of labor market reforms, as noted earlier.

The first program, denoted Program A, consists of pure labor market reform measures, which are the same in both countries in relative terms. It involves a cut in the minimum wage, as measured by a 10 percent decrease in the shift parameter w_0^U, a reduction in the unemployment benefit indexation parameters, κ^U and κ^S, by 6.25 percent (from 0.4 to 0.375), and a 37.5 percent cut in the union's untrained wage preference parameter ξ^U (a drop from from 0.16 to 0.10 for the high-income economy and from 0.08 to 0.05 for the middle-income economy).[30]

The second program, Program B1, adds human capital-promoting policies to these measures, to exploit potential gains associated with a skills expansion. Specifically, in addition to the measures in Program A, Program B1 adds an increase in specialized training time, as measured by ε, and a 5 percent reduction in specialized training cost, μ.[31] The third program, Program C1, seeks to supplement the reforms implemented in B1 with an ambitious research productivity-enhancing measure implemented across all firms in the innovation sector, which translates into a 36 percent increase in the probability of being caught shirking, π.[32] The magnitude of all these policy changes is quite large to

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et al. (2015) for instance.

[30]We consider an across-the-board cut in unemployment benefit indexation, even though we assume that reforms mainly target untrained unemployment, because this is the way these policies are implemented in practice.

[31]For the high-income economy this translates into a rise in ε from 0.1145 to 0.14, and a reduction in μ from 0.08 to 0.076. For the middle-income economy ε rises from 0.123 to 0.15 and μ falls from 0.120 to 0.114.

[32]Specifically, for the high-income economy this translates into an increase in π from 0.078 to 0.106, whereas for the middle-income economy π rises from 0.048 to 0.065.

reflect an ambitious reform agenda and by design, is largely consistent (except for π) with the individual experiments reported earlier.

The impact and steady-state effects of all three programs are shown in Table 5 whereas the transitional dynamics for both types of economies are illustrated in Figures 3, 4 and 5. The transmission mechanism of the combined shocks is, naturally enough, a composite of the features outlined earlier. The effects of Program A, which consists of pure labor market reforms, are clear: reductions in both untrained and specialized unemployment rates in both the short and the long-run—in the steady state the former (latter) drops by 6.5 percent (0.4 percent) for the high-income economy and 4.9 percent (0.1 percent) for the middle-income economy—reduced misallocation of talent, small gains in both overall specialized workers and the proportion employed in the innovation sector (despite the increase in wage premium), weak growth effects, and a deterioration in social welfare. This last result is largely due to the unemployed being worse off from the benefits cut, given the small gain in long-run growth in output and income.

As expected, the results for Program B1 show a fairly significant increase (reduction) in the supply of specialized (untrained) workers–of the order of 1.8 (2.5) percentage points for the high income economy in the long-run, and 3.3 (4.2) in the middle-income economy— and reduced misallocation of talent. The middle-income economy registers greater gains in these indicators largely due to a higher initial μ value, and a lower initial base in terms of specialized labor. By contrast, the high-income economy, with a relatively more efficient production structure, benefits from higher gains in terms of the share of specialized labor employed in the innovation sector and the growth rate of final output, which increases by 0.4 percentage points. Nevertheless, the change in welfare remains negative in both cases, and in the long run both types of economies suffer from a higher unemployment rate for specialized labor—the *oversupply* problem discussed earlier.

The more ambitious Program C1 does better in the sense that, in addition to delivering higher growth—of the order of 2.1 percentage points for the high-income economy in the long run, and 0.6 points in the middle-income economy—it lowers untrained unemployment, reduces significantly the misallocation of talent, and most importantly, also leads to improved welfare outcomes for both types of economies compared to the other programs. However, for the middle-income economy the specialized unemployment rate

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remains higher than in the initial steady state. Thus, the absorption problem noted earlier persists, despite the introduction of a research productivity-enhancing measure.

In this setting, the response to this issue is to either a) lower supply, by reducing incentives to accumulate human capital, or b) expand demand, by implementing additional policies. Regarding a), eliminating the reduction in the cost of training from Program C1 obviously leads to lower specialized unemployment in the long run—albeit at the cost of lower growth.[33] More interesting in the current economic context is to focus on b), by considering next whether a concomitant increase in public investment may provide the required stimulus.

7.2   Infrastructure Investment

We now consider whether comprehensive labor market reform programs perform better when accompanied by an increase in public infrastructure investment. The important point about this type of spending is that it has both demand-side effects (in the short run) and supply-side effects (in the long run) by boosting directly the economy's capacity to produce and by stimulating private investment through a complementarity effect. In addition, improved access to infrastructure helps to promote innovation activity, especially through a higher marginal product of capital. In addition, in our setting improved access to infrastructure helps to promote innovation activity, especially through its impact on knowledge networks, as emphasized in the recent literature.[34] In that sense, therefore, the provision of public capital is also a productivity-enhancing measure for research activities.

To examine this issue, two additional reform programs are considered: Programs B2 and C2, which add to Programs B1 and C1, respectively, a 20 percent increase in the share of public spending on infrastructure, υ_I, from 0.05 to 0.06 for the high-income economy and from 0.069 to 0.083 for the middle-income economy. The impact and long-run effects are shown also in Table 5 and the transitional dynamics are displayed in Figures 6 and 7.

The results show that for both B2 and C2 the absorption problem associated with

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[33]Specifically, for the middle-income economy the specialized unemployment rate drops by 0.5 percentage points and growth increases by 0.4 percentage points. The full results are not reported here to save space.

[34]See Agénor (2016) and the references therein. The effects of an increase in public investment, considered in isolation, are shown in Tables 3 and 4; these effects are faily muted in the case of the middle-income economy and show again conflicting effects on growth and welfare.

specialized labor is slightly mitigated. In fact, for Program C2 the specialized unemployment rate now declines both in the short and in the long run for the high-income economy (by about 0.2 percentage points in the long run), final output growth is higher (by 2.6 percentage points in the long run), and welfare improves. However, for the middle-income economy specialized unemployment still increases for both programs, by more than 2.0 percentage points in the long run.

As noted earlier, addressing the labor absorption issue could be achieved by mitigating incentives to acquire skills (namely, by keeping the cost of training high). The question here is whether more aggressive policies aimed at increasing labor demand in both the innovation and final good sectors can prevent a rise in specialized unemployment—even when training costs are lowered as before. Indeed, consider Program C2 and suppose that public investment in infrastructure is now increased from 2.0 percent of GDP to 6.2 percent—which translates into an increase in v_I from 6.9 percent of noninterest public expenditure to 21.0 percent—a value consistent with the upper range of estimates reported by Serebrisky et al. (2015, p. 7) and deemed necessary in a number of policy reports to eliminate Latin America's infrastructure gap with respect to East Asia.. In addition, suppose that through governance reforms public investment efficiency, as measured by φ, is increased in all countries from 0.4 to the level of Brazil's, as estimated by Dabla-Norris et al. (2012, Table 1), that is, 0.78, and that labor productivity in the innovation sector is increased by raising research monitoring intensity to the same baseline level of the high-income economy (that is, an increase in π from 0.048 to 0.078, instead of 0.065). The higher stock of public capital contributes to higher productivity in both the final good and innovation sectors (with the latter also benefiting from increased monitoring intensity), which improves the middle-income economy's ability to absorb specialized labor. However, despite higher long-run growth and welfare, this program is still unable to generate a large drop in specialized unemployment.[35] Moreover, it is an open question as to whether, in practice, a program involving a permanent increase in the ratio of investment to GDP to more than 6 percent is sustainable politically. The broader lesson from this experiment is therefore that in middle-income economies ambitious reforms aimed

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[35]Specifically, in the long run the specialized unemployment rate drops by 0.1 percentage points (compared to -6.6 points for untrained labor), while growth increases by 6.8 percentage points and welfare by 4.9 percentage points. Again, the full results are not reported here to save space.

at increasing efficiency, both in the public and private sector, are important to promote labor demand and growth, but that caution is also needed in promoting higher education through reductions in tuition fees, to avoid creating an oversupply of specialized workers. In many of these countries, improving the quality of education may prove more effective.

It is worth noting also from Figures 3 to 7 that the transitional dynamics associated with the composite programs, with or without public investment in infrastructure, are largely monotonic, except for the growth rate of output which follows an inverted U-shape—growth accelerates during the first phase of the transition, but slows down gradually in the second phase. In addition, the adjustment path is very similar for all the variables shown in the figures—except for the wage premium and the specialized unemployment rate for the middle-income economy when public investment is added to the composite labor market reform programs.

The U-shape path of output growth largely reflects the composition of the reform programs. During the first phase of the transition, the effects of policy reforms on skills expansion and employment tend to dominate. The easing of labor market rigidities (reductions in the minimum wage and union bargaining power) and active labor market policies (cut in training cost) raise incentives to acquire advanced skills. At the same time, the drop in the marginal cost of hiring specialized labor leads to the hiring of more of that type of workers in the final good and innovation sectors. In the case of the latter, these reforms complement the policy aimed to improve research monitoring intensity and the expansion of innovation activity. The combination of these effects translates into a sharp growth acceleration. During the second phase of the transition, however, these effects are mitigated. The labor market reforms lead to an overshooting in specialized wages and therefore to too much specialized labor in the economy, outpacing the expansion in demand and thereby putting downward pressure on specialized wages. At the same time, the marginal product of untrained labor in the final good sector improves, thereby raising the effective wage of that category of workers. This leads to a reduction in incentives to acquire skills, and a reduced supply of specialized labor—which in turn rekindles upward pressure on specialized wages and translates into reduced labor demand in the innovation sector. The expansion of intermediate varieties therefore decelerates over time, resulting in a gradual slowdown in output growth.

7.3 Policy Externalities

Finally, a question worth asking is to what extent composite reform programs generate long-run gains that exceed those generated by independent policies? This issue can be addressed in a simple manner by adding up the steady-state results for each individual policy in a composite program with respect to a particular set of variables, and comparing the aggregate numbers with those reported in Table 5 for the relevant program. The difference between the latter and the sum of individual effects gives a measure of interactions between reforms and (depending on its sign) whether they complement or offset each other, that is, whether policy externalities are positive or negative.

For Program C2 for instance, for the high-income economy the sum of partial effects gives a total of 0.0227 for the growth rate (compared to 0.0261 in Table 5), -0.0686 for the aggregate unemployment rate (compared to -0.0551) and 0.0619 for social welfare (compared to 0.0186). For the middle-income economy and for the same program, the sum of partial effects gives 0.0065 for the growth rate (compared to 0.0083), -0.0513 for the aggregate unemployment rate (compared to -0.0384), and 0.0431 for social welfare (compared to 0.0280). These comparisons suggest therefore that whether externalities are positive or negative the benefits of comprehensive programs depend on which outcomes one chooses to focus on; in terms of growth, integrated programs perform better because they generate positive externalities. In terms of unemployment or welfare, however, integrated programs perform worse.[36] Intuitively, policies aimed at cutting unemployment benefits and diluting union bargaining power for untrained workers tend to be associated with drops in wages and consumption for the unemployed and untrained groups–despite the fact that they are complementary to other policies in promoting innovation and specialized employment. Similarly, while combining either skills expansion policies (cuts in training cost) or productivity-enhancing measures (improvement in research monitoring) with conventional labor market policies tends to create positive externalities in terms of growth and talent allocation, these policies also produce counteracting effects on the specialized wage premium. Consequently, instead of a complementarity effect, they generate a negative externality which contributes to weaker outcomes for the composite program

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[36]Similar results hold for the other composite programs considered earlier. They are not reported here to save space.

in terms of its impact on (untrained) unemployment and social welfare.

8   Concluding Remarks

The main implications of this paper were summarized in the introduction and need not be repeated here. We therefore conclude by pointing out that the model could be extended to account for other types of labor market distortions, such as state-contingent firing costs and severance payments, deskilling of the labor force associated with unemployment, as well as a positive effect of a higher share of more educated workers on life expectancy and savings (and thus on economic growth), and various other forms of active labor market policies (see Almeida et al. (2012)). In particular, hiring and firing regulations, and hiring costs, have been shown to have an adverse effect on unemployment, especially when search and matching considerations are important;[37] their implications for growth and welfare, however, are less well understood.

A more systematic effort to integrate political economy considerations in assessing the performance of labor market reforms in growth models would also be warranted. Observers have often argued that the costs of these reforms are incurred up front and concentrated on specific groups, whereas their benefits materialize later and are both more diffuse and less predictably allocated among workers and households. In addition, conflicting growth and welfare effects may well lead to organized resistance to reform. A key challenge then is to create the political consensus needed to confront powerful vested interests and mitigate dynamic trade-offs between (short-term) costs and (longer-term) gains.

At the same time, if specific labor market reforms do not produce substantial economic benefits—as suggested by our numerical experiments—political viability may well require reform programs to eschew them and focus instead on upfront measures that matter more for productivity, especially in research and innovation. Put differently, with limited political capital and little capacity to compensate losers in the short run, pursuing a wide array of labor market reforms at once may prove costly and ineffective. Moreover, even when there is broad support for reform, weak administrative capacity and inade-

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[37]See Bernal-Verdugo et al. (2012) and Millána et al. (2014) for some supportive evidence. However, other studies provide a mixed picture; see International Labour Office (2012) for a discussion.

quate governance—key constraints in many middle-income countries—militate in favor of a narrow reform agenda. While a full treatment of these issues is beyond the scope of this paper, they deserve greater attention going forward.

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Table 1
Calibrated Parameter Values: Benchmark Case

Parameter	Description	High Income	Middle Income
Households			
ρ	Intergenerational discount rate	0.375	0.375
σ	Household savings rate	0.109	0.138
χ	Productivity parameter (efficiency of training)	0.9	0.5
μ	Advanced education cost	0.08	0.12
ε	Time allocated to schooling activity	0.115	0.123
Final good			
ω	Elasticity wrt public-private capital ratio	0.17	0.24
β^S	Elasticity wrt specialized workers	0.3	0.35
β^U	Elasticity wrt untrained workers	0.3	0.2
α	Elasticity wrt private capital	0.3	0.35
γ	Elasticity wrt intermediate input	0.1	0.1
Intermediate goods			
η	Substitution parameter, intermediate goods	0.61	0.25
Innovation sector			
ϕ_1^R	Elasticity wrt public infrastructure	0.186	0.300
π	Probability of being caught shirking	0.078	0.048
δ_R	Elasticity wrt wage for innovation	0.9	0.9
λ	Elasticity of production wrt labor input	0.6	0.6
ψ	Elasticity of effort wrt relative wages	0.70	0.43
Government			
τ	Tax rate on total wages	0.198	0.123
υ_I	Share of spending on infrastructure	0.050	0.069
φ	Efficiency parameter, public investment	0.5	0.4
Labor market			
κ^S	Specialized labor, unemp. benefit indexation	0.4	0.4
κ^U	Untrained labor, unemp. benefit indexation	0.4	0.4
ξ^U	Relative weight, untrained workers	0.06	0.08
ξ^{SY}	Relative weight, specialized workers	0.06	0.08
w_0^U	Minimum wage indexation, untrained workers	0.522	0.546
w_0^{SY}	Minimum wage indexation, specialized workers	0.740	0.699
$\varkappa^U$	Elasticity wrt unemployment, untrained wage	0.12	0.12
$\varkappa^S$	Elasticity wrt unemployment, specialized wage	0.12	0.12

Table 2

Initial Steady-State Values of Key Variables

Variable	Description	High Income	Middle Income
θ^U	Share of untrained workers in population	0.732	0.795
θ^S	Share of effective specialized workers in population	0.232	0.184
θ^{SR}	Share of effective specialized workers in innovation sector	0.019	0.004
θ^{SY}	Share of effective specialized workers in final good sector	0.145	0.109
θ^{UY}	Share of untrained workers in final good sector	0.606	0.708
θ^{UL}	Untrained unemployment rate	0.126	0.087
θ^{SL}	Specialized unemployment rate	0.068	0.071
$(\theta^R - \theta^{SR})/\theta^{SY}$	Index of misallocation of talent	0.189	0.392
ζ^{SL}	Probability of specialized workers getting unemployed	0.293	0.385
ζ^{SY}	Prob. of specialized workers employed in final good sector	0.623	0.593
ζ^{SR}	Prob. of specialized workers employed in innovation sector	0.084	0.022
ζ^{UL}	Prob. of untrained workers getting unemployed	0.172	0.110
ζ^{UY}	Prob. of untrained workers getting employed	0.828	0.890
ς	Firms' payroll contribution rate	0.126	0.052
$w^U/w^S_{weighted}$	Relative wage ratio	0.550	0.750
k^G	Public-private capital ratio	0.189	0.147
Y/K^P	Final output-private capital ratio	0.286	0.429
m	Stock of innovation-private capital ratio	0.100	0.100

Table 3
High-Income Economy: Summary of Benchmark Individual Policy Experiments*
[Absolute deviations from baseline]

	Steady state	Reduction in Base Minimum Wage		Reduction in Untrained Workers' UB Indexation		Reduction in Specialized Workers' UB Indexation	
	value	Impact	Steady State	Impact	Steady State	Impact	Steady State
Share of untrained workers	0.7320	-0.0008	-0.0030	-0.0008	-0.0019	0.0013	0.0028
Effective share of specialized workers	0.2321	0.0006	0.0022	0.0006	0.0014	-0.0009	-0.0020
Share of specialized workers in innovation	0.0194	0.0001	0.0008	0.0003	0.0005	0.0004	0.0003
Expected wage premium	0.8182	0.0062	0.0181	0.0140	0.0116	-0.0168	-0.0082
Index of misallocation of talent	0.1890	-0.0018	-0.0089	-0.0027	-0.0058	-0.0028	-0.0021
Untrained unemployment rate	0.1260	-0.0115	-0.0278	-0.0015	-0.0059	-0.0003	-0.0007
Specialized unemployment rate	0.0680	-0.0002	-0.0011	-0.0004	-0.0007	-0.0014	-0.0025
Total unemployment rate	0.1058	-0.0082	-0.0199	-0.0012	-0.0044	-0.0005	-0.0011
Payroll contribution rate	0.1260	-0.0052	-0.0212	-0.0064	-0.0137	-0.0037	-0.0072
Growth rate of final output	0.0080	0.0073	0.0010	-0.0050	0.0006	-0.0061	0.0003
Social welfare	1.0000		0.0046		-0.0872		-0.1667

	Steady state	Reduction in both UB Indexation Parameters		Reduction in Untrained Workers' Union Mark-up		Reduction in Specialized Workers' Union Mark-up	
	value	Impact	Steady State	Impact	Steady State	Impact	Steady State
Share of untrained workers	0.7320	0.0005	0.0008	-0.0004	-0.0016	0.0006	0.0013
Effective share of specialized workers	0.2321	-0.0003	-0.0006	0.0003	0.0012	-0.0004	-0.0009
Share of specialized workers in innovation	0.0194	0.0006	0.0008	0.0001	0.0004	0.0001	0.0001
Expected wage premium	0.8182	-0.0028	0.0034	0.0032	0.0095	-0.0079	-0.0038
Index of misallocation of talent	0.1890	-0.0055	-0.0078	-0.0009	-0.0047	-0.0047	-0.0048
Untrained unemployment rate	0.1260	-0.0017	-0.0065	-0.0060	-0.0147	-0.0001	-0.0003
Specialized unemployment rate	0.0680	-0.0018	-0.0032	-0.0001	-0.0006	-0.0036	-0.0042
Total unemployment rate	0.1058	-0.0017	-0.0054	-0.0042	-0.0105	-0.0010	-0.0012
Payroll contribution rate	0.1260	-0.0102	-0.0206	-0.0027	-0.0113	-0.0017	-0.0033
Growth rate of final output	0.0080	-0.0111	0.0009	0.0038	0.0005	0.0094	0.0001
Social welfare	1.0000		-0.2383		0.0024		-0.0185

	Steady state	Higher Labor Productivity in Innovation		Advanced Education Cost Cut		Increase in Public Infrastructure Investment	
	value	Impact	Steady State	Impact	Steady State	Impact	Steady State
Share of untrained workers	0.7320	-0.0024	-0.0059	-0.0098	-0.0224	-0.0005	-0.0012
Effective share of specialized workers	0.2321	0.0018	0.0043	0.0071	0.0161	0.0004	0.0009
Share of specialized workers in innovation	0.0194	0.0039	0.0047	0.0012	0.0029	0.0019	0.0021
Expected wage premium	0.8182	0.0477	0.0361	-0.0504	-0.0988	0.0100	0.0079
Index of misallocation of talent	0.1890	-0.0272	-0.0332	-0.0098	-0.0235	-0.0128	-0.0143
Untrained unemployment rate	0.1260	-0.0015	-0.0069	-0.0033	-0.0155	-0.0004	-0.0018
Specialized unemployment rate	0.0680	-0.0021	-0.0013	0.0048	0.0102	-0.0014	-0.0013
Total unemployment rate	0.1058	-0.0017	-0.0054	-0.0013	-0.0084	-0.0006	-0.0017
Payroll contribution rate	0.1260	-0.0037	-0.0096	0.0004	-0.0048	-0.0013	-0.0032
Growth rate of final output	0.0080	0.0078	0.0125	0.0010	0.0027	0.0346	0.0031
Social welfare	1.0000		0.1865		0.0075		0.0027

*/ The respective individual policy shocks are: Reduction in w_{U_o} by 5 percent; κ^U reduced by 10 percent;

κ^S reduced by 10 percent; both κ^U and κ^S cut by 10 percent; ξ^U reduced by 37.5 percent; ξ^{SY} reduced by 37.5 percent;

translates to an increase in probability of getting caught shirking by 28.6 percent; decrease in advanced education cost by 5 percent;

and an increase in share of public infrastructure investment by 20 percent.

Source: Authors' calculations.

Table 4

Middle-Income Economy: Summary of Benchmark Individual Policy Experiments*
[Absolute deviations from baseline]

	Steady state	Reduction in Base Minimum Wage		Reduction in Untrained Workers' UB Indexation		Reduction in Specialized Workers' UB Indexation	
	value	Impact	Steady State	Impact	Steady State	Impact	Steady State
Share of untrained workers	0.7950	-0.0005	-0.0014	-0.0003	-0.0007	0.0010	0.0023
Effective share of specialized workers	0.1840	0.0004	0.0011	0.0003	0.0006	-0.0008	-0.0019
Share of specialized workers in innovation	0.0040	0.0000	0.0001	0.0000	0.0001	0.0001	0.0000
Expected wage premium	0.3333	0.0021	0.0076	0.0055	0.0038	-0.0214	-0.0155
Index of misallocation of talent	0.3922	-0.0010	-0.0039	-0.0011	-0.0020	-0.0008	-0.0003
Untrained unemployment rate	0.0870	-0.0085	-0.0201	-0.0004	-0.0016	0.0000	0.0001
Specialized unemployment rate	0.0710	0.0002	0.0002	0.0000	0.0001	-0.0009	-0.0019
Total unemployment rate	0.0791	-0.0065	-0.0154	-0.0003	-0.0012	-0.0002	-0.0003
Payroll contribution rate	0.0520	-0.0019	-0.0073	-0.0020	-0.0037	-0.0018	-0.0032
Growth rate of final output	0.0390	0.0033	0.0001	-0.0020	0.0001	-0.0064	0.0001
Social welfare	1.0000		0.0040		-0.0761		-0.2216

	Steady state	Reduction in both UB Indexation Parameters		Reduction in Untrained Workers' Union Mark-up		Reduction in Specialized Workers' Union Mark-up	
	value	Impact	Steady State	Impact	Steady State	Impact	Steady State
Share of untrained workers	0.7950	0.0007	0.0016	-0.0004	-0.0010	0.0005	0.0012
Effective share of specialized workers	0.1840	-0.0006	-0.0013	0.0003	0.0008	-0.0004	-0.0009
Share of specialized workers in innovation	0.0040	0.0001	0.0001	0.0000	0.0001	0.0000	0.0000
Expected wage premium	0.3333	-0.0160	-0.0117	0.0016	0.0056	-0.0106	-0.0077
Index of misallocation of talent	0.3922	-0.0019	-0.0023	-0.0007	-0.0029	-0.0120	-0.0120
Untrained unemployment rate	0.0870	-0.0004	-0.0015	-0.0063	-0.0150	0.0000	0.0000
Specialized unemployment rate	0.0710	-0.0009	-0.0018	0.0001	0.0001	-0.0038	-0.0044
Total unemployment rate	0.0791	-0.0005	-0.0015	-0.0048	-0.0114	-0.0007	-0.0007
Payroll contribution rate	0.0520	-0.0038	-0.0069	-0.0014	-0.0054	-0.0009	-0.0016
Growth rate of final output	0.0390	-0.0082	0.0001	0.0024	0.0001	0.0149	0.0000
Social welfare	1.0000		-0.2788		0.0030		-0.0256

	Steady state	Higher Labor Productivity in Innovation		Advanced Education Cost Cut		Increase in Public Infrastructure Investment	
	value	Impact	Steady State	Impact	Steady State	Impact	Steady State
Share of untrained workers	0.7950	-0.0006	-0.0013	-0.0192	-0.0426	-0.0001	-0.0003
Effective share of specialized workers	0.1840	0.0004	0.0010	0.0151	0.0330	0.0001	0.0002
Share of specialized workers in innovation	0.0040	0.0013	0.0014	0.0007	0.0015	0.0006	0.0006
Expected wage premium	0.3333	0.0095	0.0066	-0.0834	-0.1608	0.0021	0.0014
Index of misallocation of talent	0.3922	-0.0120	-0.0129	-0.0134	-0.0273	-0.0053	-0.0055
Untrained unemployment rate	0.0870	-0.0002	-0.0010	-0.0042	-0.0196	-0.0001	-0.0003
Specialized unemployment rate	0.0710	-0.0008	-0.0004	0.0124	0.0274	-0.0004	-0.0004
Total unemployment rate	0.0791	-0.0003	-0.0009	-0.0006	-0.0079	-0.0001	-0.0003
Payroll contribution rate	0.0520	-0.0006	-0.0011	0.0017	0.0026	-0.0002	-0.0004
Growth rate of final output	0.0390	0.0018	0.0033	0.0044	0.0012	0.0496	0.0009
Social welfare	1.0000		0.1334		0.0610		-0.0019

*/ The respective individual policy shocks are: Reduction in w_{U_o} by 5 percent; κ^U reduced by 10 percent;

κ^S reduced by 10 percent; both κ^U and κ^S cut by 10 percent; ξ^U reduced by 37.5 percent; ξ^{SY} reduced by 37.5 percent;

translates to an increase in probability of getting caught shirking by 28.6 percent; decrease in advanced education cost by 5 percent;

and an increase in share of public infrastructure investment by 20 percent.

Source: Authors' calculations.

Table 5
Summary of Benchmark Composite Reform Programs*
[Absolute deviations from baseline]

High-Income Economy	Steady state	Program A		Program B1		Program B2		Program C1		Program C2	
	value	Impact	Steady State	Impact	Steady State	Impact	Steady State	Impact	Steady State	Impact	Steady State
Share of untrained workers	0.7320	-0.0015	-0.0056	-0.0101	-0.0248	-0.0106	-0.0261	-0.0131	-0.0327	-0.0138	-0.0346
Effective share of specialized workers	0.2321	0.0011	0.0041	0.0073	0.0179	0.0077	0.0188	0.0095	0.0234	0.0100	0.0248
Share of specialized workers in innovation	0.0194	0.0007	0.0023	0.0012	0.0043	0.0033	0.0068	0.0061	0.0109	0.0087	0.0142
Expected wage premium	0.8182	0.0125	0.0402	-0.0047	-0.0270	0.0058	-0.0190	0.0557	0.0186	0.0721	0.0315
Index of misallocation of talent	0.1890	-0.0077	-0.0228	-0.0166	-0.0424	-0.0296	-0.0581	-0.0486	-0.0845	-0.0652	-0.1057
Untrained unemployment rate	0.1260	-0.0288	-0.0651	-0.0312	-0.0736	-0.0316	-0.0746	-0.0326	-0.0781	-0.0331	-0.0795
Specialized unemployment rate	0.0680	-0.0016	-0.0043	-0.0006	0.0011	-0.0021	-0.0004	-0.0031	-0.0004	-0.0049	-0.0023
Total unemployment rate	0.1058	-0.0207	-0.0467	-0.0222	-0.0505	-0.0228	-0.0516	-0.0238	-0.0537	-0.0246	-0.0551
Payroll contribution rate	0.1260	-0.0185	-0.0544	-0.0191	-0.0566	-0.0203	-0.0586	-0.0229	-0.0627	-0.0245	-0.0653
Growth rate of final output	0.0080	0.0105	0.0026	0.0110	0.0038	0.0461	0.0073	0.0202	0.0208	0.0551	0.0261
Social welfare	1.0000		-0.1471		-0.1738		-0.1717		0.0153		0.0186
Middle-Income Economy	Steady state	Program A		Program B1		Program B2		Program C1		Program C2	
	value	Impact	Steady State	Impact	Steady State	Impact	Steady State	Impact	Steady State	Impact	Steady State
Share of untrained workers	0.7950	-0.0009	-0.0021	-0.0192	-0.0421	-0.0194	-0.0426	-0.0201	-0.0444	-0.0203	-0.0452
Effective share of specialized workers	0.1840	0.0007	0.0017	0.0151	0.0326	0.0152	0.0329	0.0157	0.0343	0.0159	0.0349
Share of specialized workers in innovation	0.0040	0.0001	0.0003	0.0007	0.0017	0.0014	0.0025	0.0026	0.0041	0.0036	0.0054
Expected wage premium	0.3333	-0.0051	0.0098	-0.0666	-0.1349	-0.0644	-0.1336	-0.0541	-0.1267	-0.0500	-0.1242
Index of misallocation of talent	0.3922	-0.0037	-0.0099	-0.0254	-0.0439	-0.0313	-0.0512	-0.0420	-0.0650	-0.0505	-0.0758
Untrained unemployment rate	0.0870	-0.0225	-0.0487	-0.0256	-0.0588	-0.0257	-0.0590	-0.0259	-0.0595	-0.0260	-0.0598
Specialized unemployment rate	0.0710	-0.0002	-0.0007	0.0087	0.0220	0.0082	0.0215	0.0076	0.0212	0.0068	0.0205
Total unemployment rate	0.0791	-0.0173	-0.0374	-0.0174	-0.0376	-0.0176	-0.0378	-0.0178	-0.0381	-0.0180	-0.0384
Payroll contribution rate	0.0520	-0.0071	-0.0200	-0.0059	-0.0161	-0.0061	-0.0164	-0.0066	-0.0172	-0.0069	-0.0177
Growth rate of final output	0.0390	0.0034	0.0004	0.0072	0.0013	0.0577	0.0024	0.0093	0.0064	0.0596	0.0083
Social welfare	1.0000		-0.1673		-0.1169		-0.1180		0.0305		0.0280

*/ Program A includes a decrease in κ^S by 6.25 percent; a decrease in κ^U by 6.25 percent; a decrease in w_{U0} by 10 percent; and a reduction in untrained union mark-up by 37.5 percent.

Program B1 includes a decrease in μ by 5 percent; an increase in advanced education period by 22 percent; a decrease in κ^S by 6.25 percent; a decrease in κ^U by 6.25 percent;

a decrease in w_{U_0} by 10 percent; and a reduction in untrained union mark-up by 37.5 percent;

Program B2 adds an increase in public infrastructure investment by 20 percent to Program B1.

Program C1 adds to Program B1, the implementation of performance management measures leading to an improved labor productivity in innovation (increase in π

by 36 percent). Program C2 adds a positive infrastructure investment shock by 20 percent to Program C1.

Source: Authors' calculations.

Figure 1
Production Structure and the Labor Market
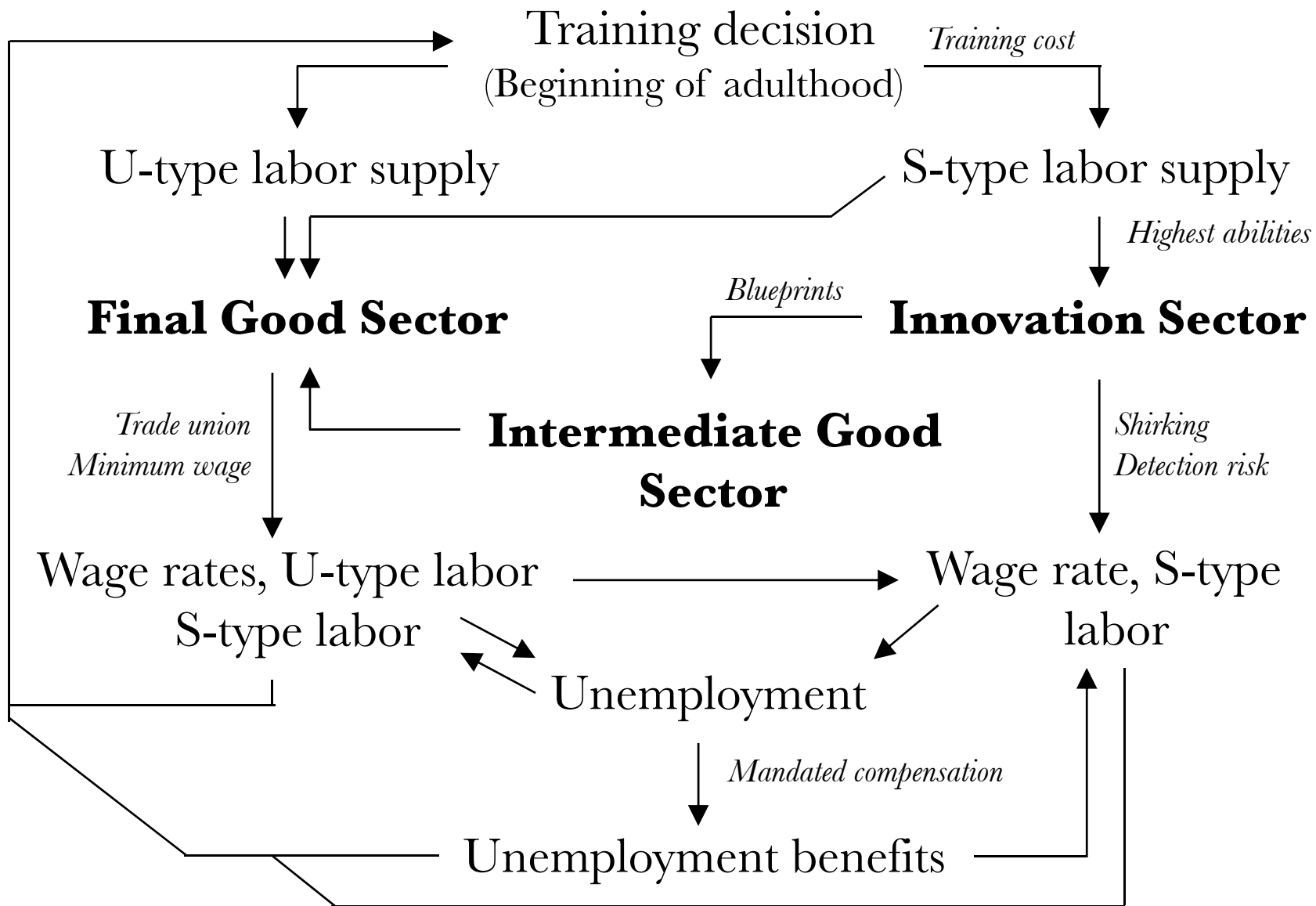
Figure 2
Individual and Composite Experiments: Steady-state effects
(Absolute deviations from baseline)
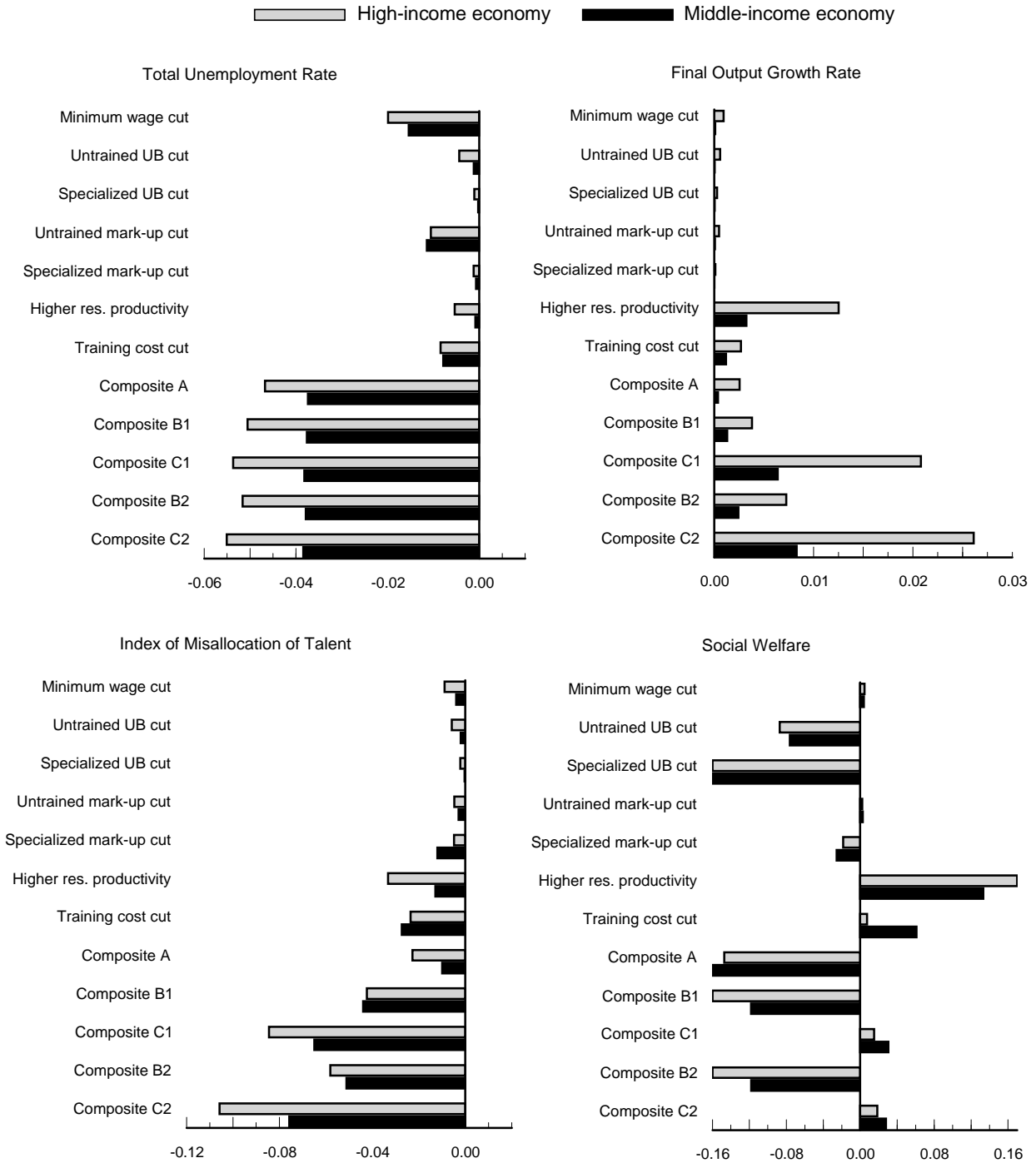
Source: Authors' calculation.

Figure 3
Composite Reform Program A
(Absolute deviations from baseline)
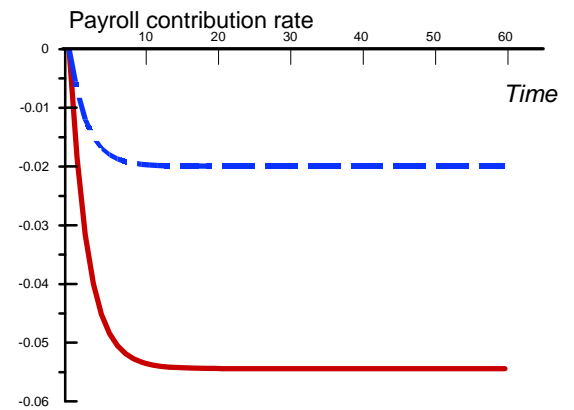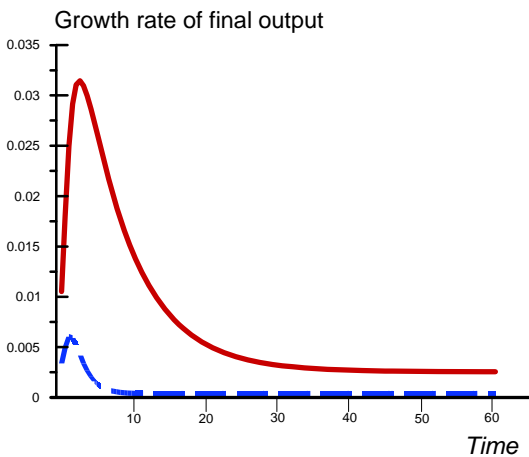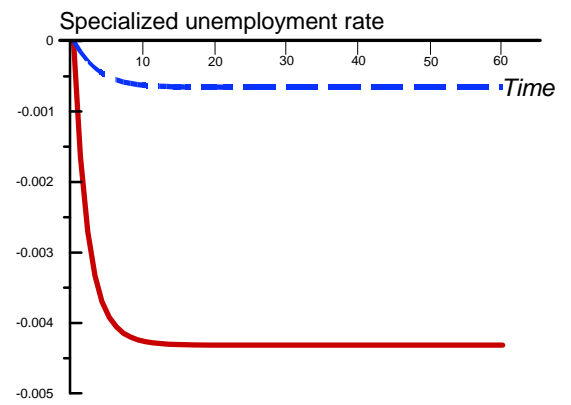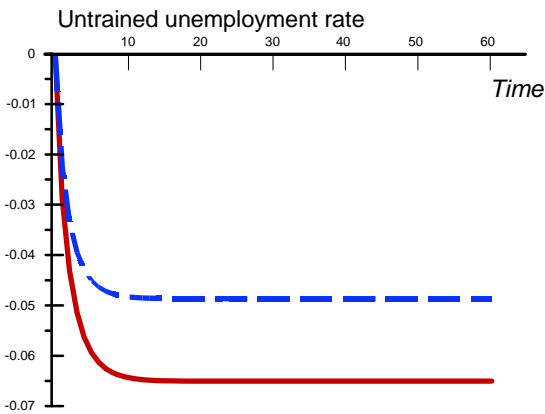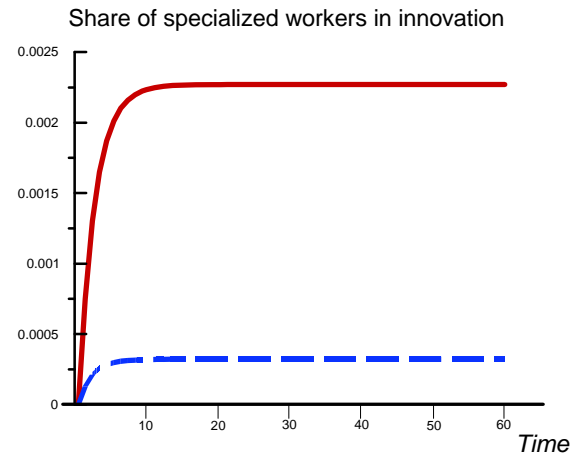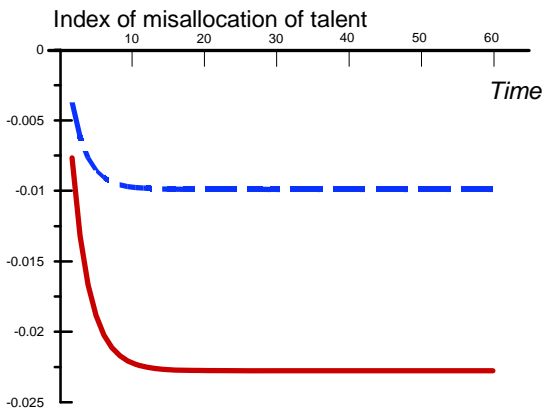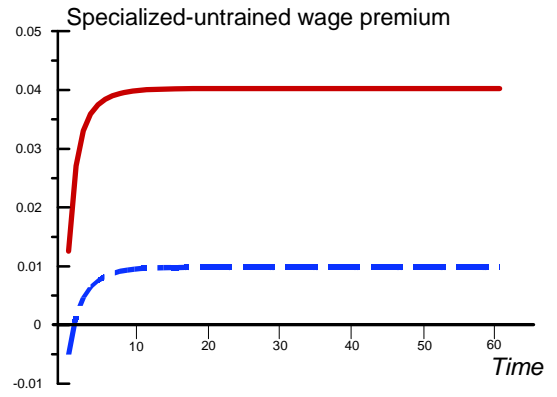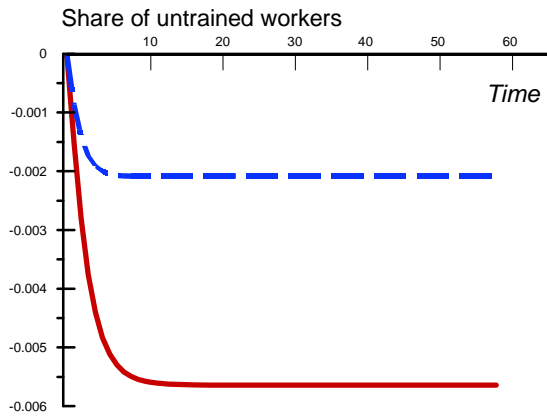

High-income economy Middle-income economy

Share of untrained workers
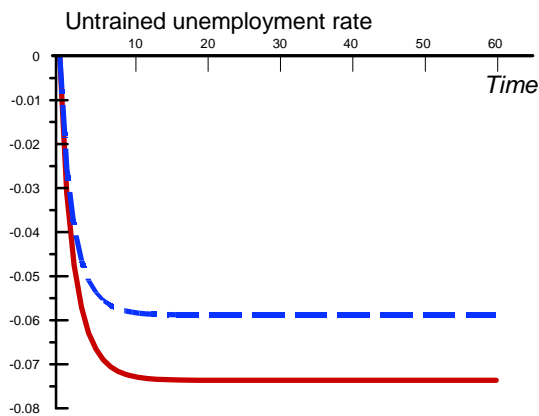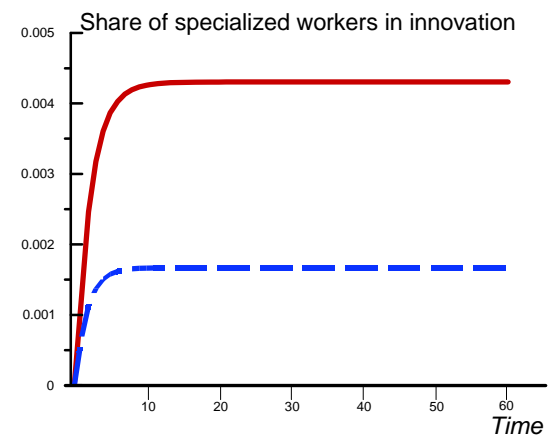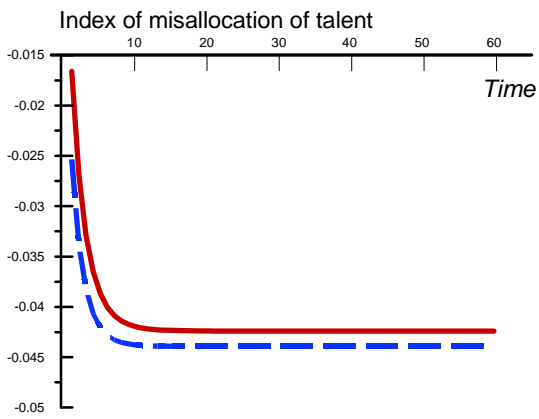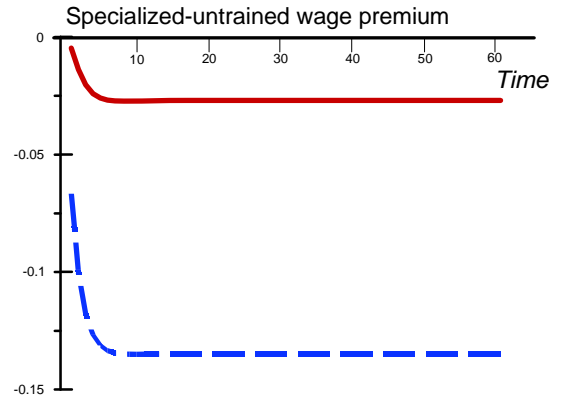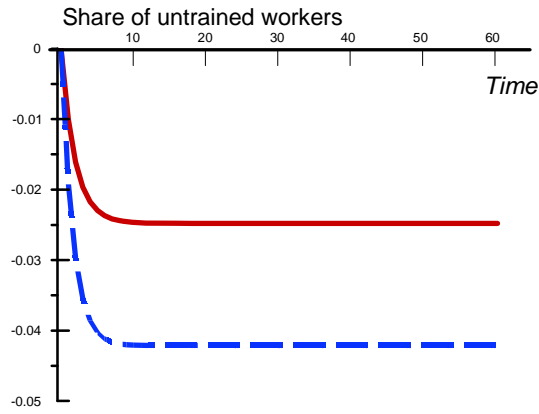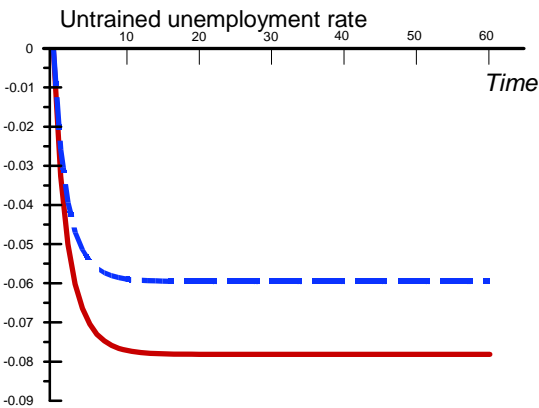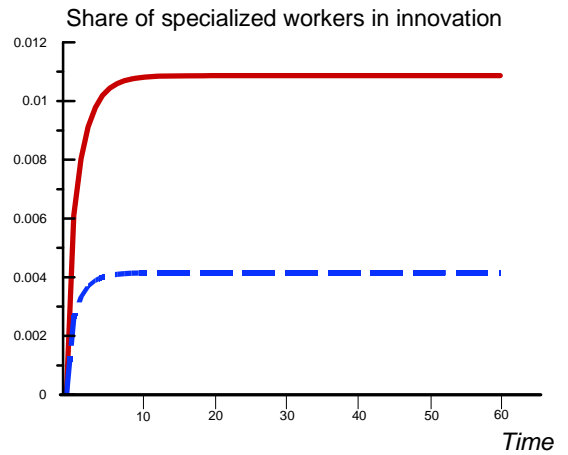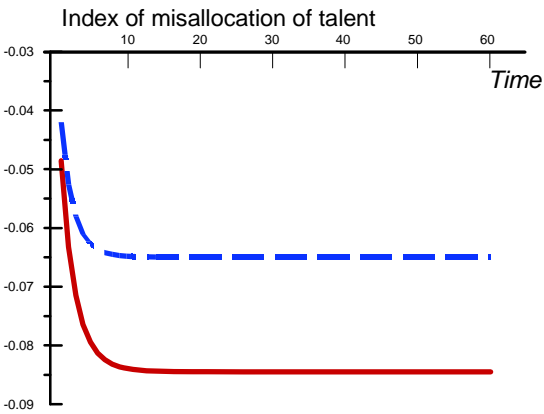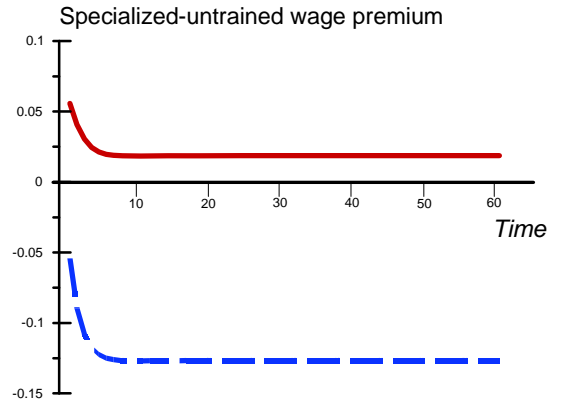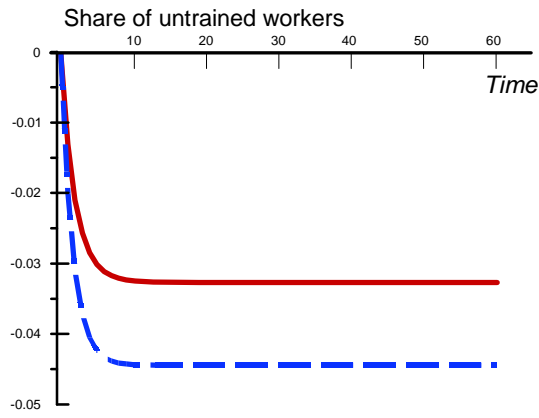
Specialized-untrained wage premium

Index of misallocation of talent

Share of specialized workers in innovation

Untrained unemployment rate

Specialized unemployment rate

Growth rate of final output

Payroll contribution rate

Figure 4
Composite Reform Program B1
(Absolute deviations from baseline)

Legend: High-income economy (solid red line); Middle-income economy (dashed blue line)

Panels: Share of untrained workers; Specialized-untrained wage premium; Index of misallocation of talent; Share of specialized workers in innovation; Untrained unemployment rate; Specialized unemployment rate; Growth rate of final output; Payroll contribution rate
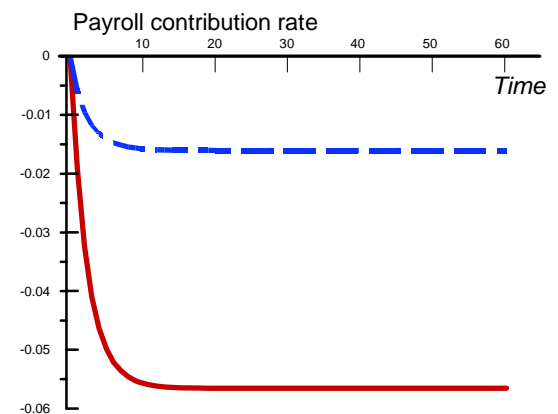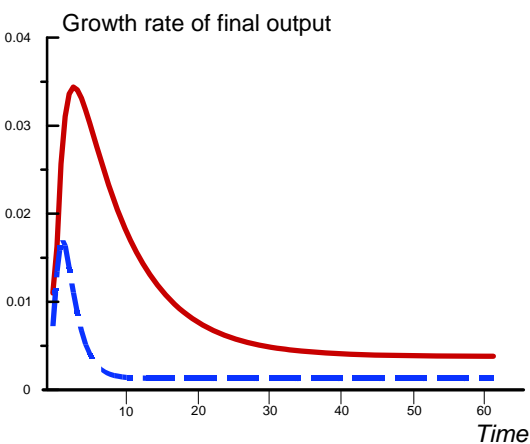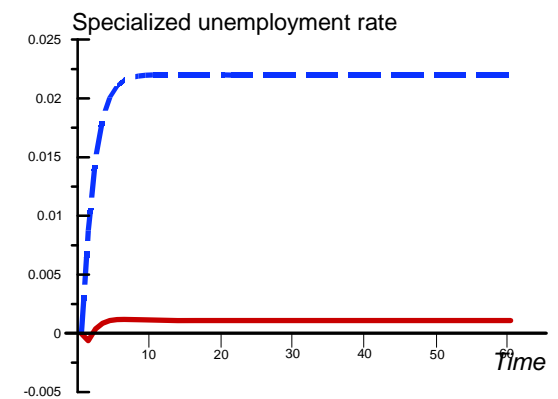
Figure 5
Composite Reform Program C1
(Absolute deviations from baseline)
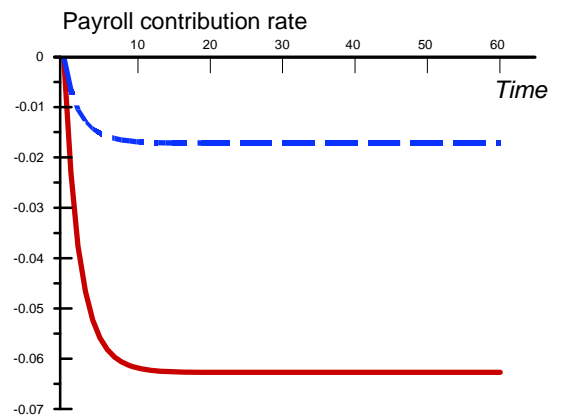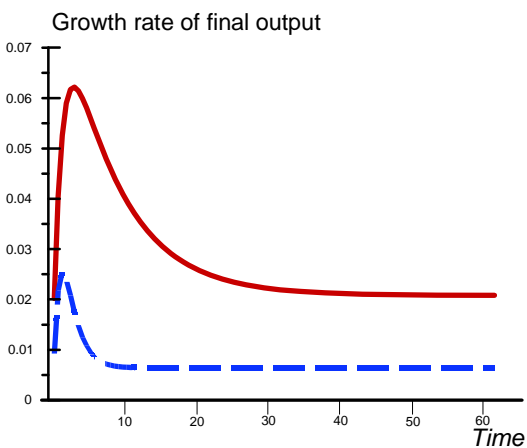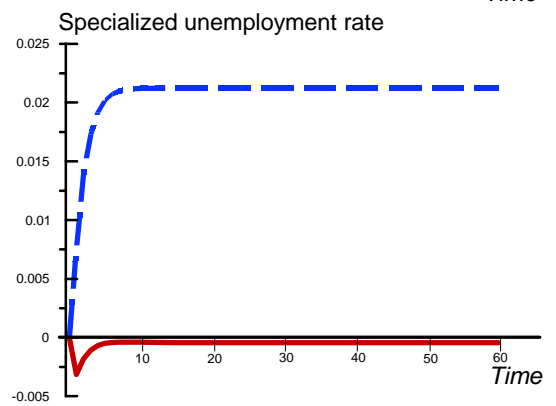
Figure 6
Composite Reform Program B2
(Absolute deviations from baseline)
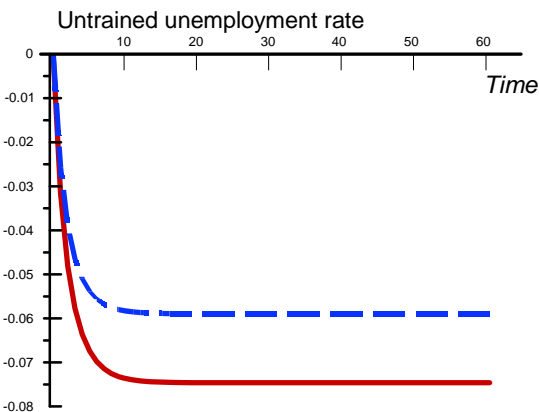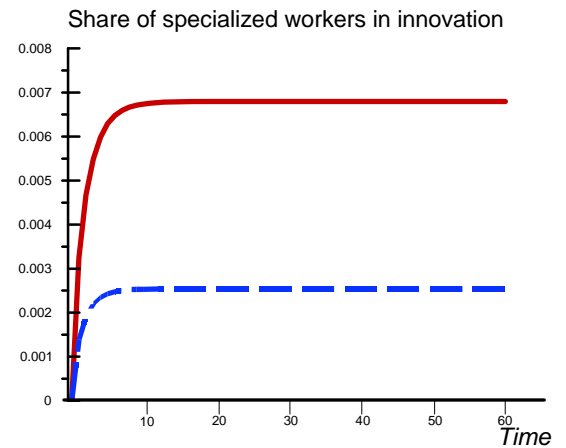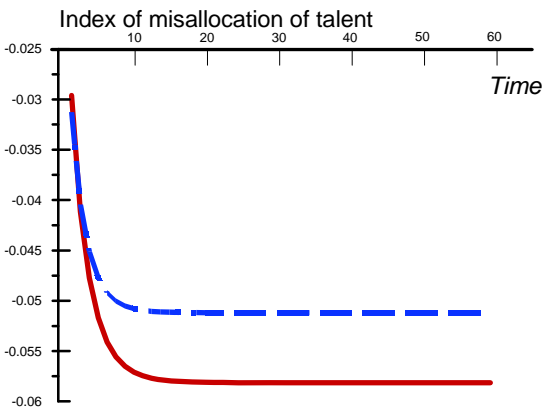

High-income economy —— Middle-income economy - - -

Share of untrained workers

Specialized-untrained wage premium

Index of misallocation of talent

Share of specialized workers in innovation

Untrained unemployment rate

Specialized unemployment rate

Growth rate of final output

Payroll contribution rate
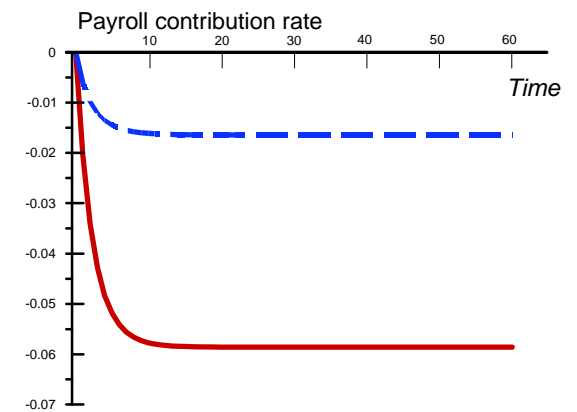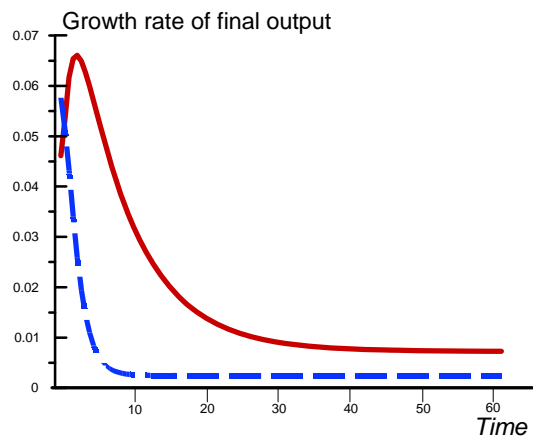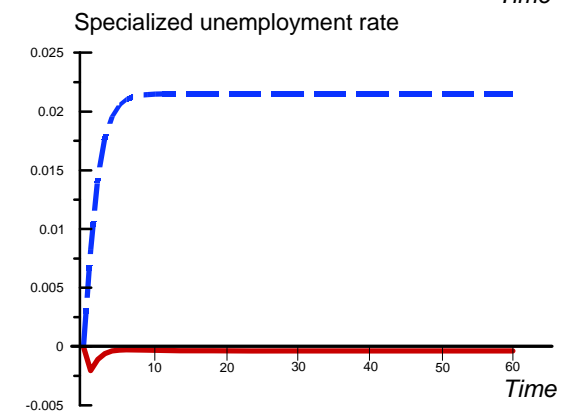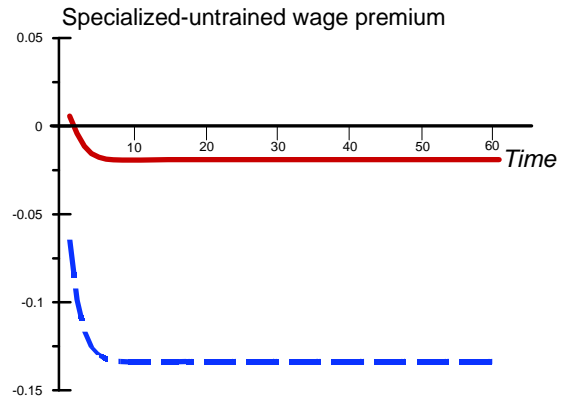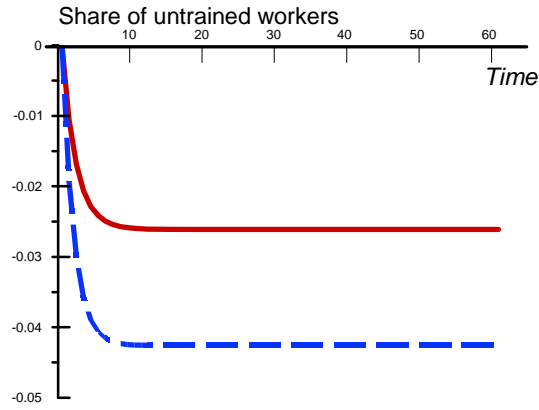
Figure 7
Composite Reform Program C2
(Absolute deviations from baseline)

——— High-income economy   – – – Middle-income economy

Share of untrained workers

Specialized-untrained wage premium

Index of misallocation of talent

Share of specialized workers in innovation

Untrained unemployment rate

Specialized unemployment rate

Growth rate of final output

Payroll contribution rate